Annual Report

New York (State) Dept. of Agriculture

State of New York—Department of Agriculture

18th report - V. 3

TWENTY-NINTH ANNUAL REPORT

OF THE

New York Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY)

FOR THE YEAR 1910

With Reports of Director and Other Officers

TRANSMITTED TO THE LEGISLATURE JANUARY 16, 1911

ALBANY
J. B. LYON COMPANY, STATE PRINTERS
1911

STATE OF NEW YORK

No. 25.

IN ASSEMBLY

JANUARY 16, 1911.

TWENTY-NINTH ANNUAL REPORT

OF THE

New York Agricultural Experiment Station.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 16, 1911.

To the Assembly of the State of New York:

I have the honor to herewith submit the Twenty-ninth Annual Report of the Board of Control of the New York Agricultural Experiment Station at Geneva, N. Y., as a part of the Eighteenth Annual Report of the Department of Agriculture, in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

R. A. PEARSON,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION.

W. H. JORDAN, *Director*.

GENEVA, N. Y., *January* 10, 1911.

Hon. RAYMOND A. PEARSON, *Commissioner of Agriculture, Albany, N. Y.:*

DEAR SIR.— I have the honor to transmit herewith the report of the New York Agricultural Experiment Station for the year 1910, in accordance with the provisions of section 306 of the Agricultural Law.

Yours respectfully,

T. B. WILSON,
President, Board of Control.

ORGANIZATION OF THE STATION 1910.

BOARD OF CONTROL.

Governor Horace White, Albany.
Commissioner Raymond A. Pearson, Albany.
Lyman P. Haviland, Camden.
Edgar G. Dusenbury, Portville.
Thomas B. Wilson, Hall.
Irving Rouse, Rochester.
Alfred G. Lewis, Geneva.
Lewis L. Morrell, Kinderhook.
Elihu S. Miller, Wading River.

OFFICERS OF THE BOARD.

Thomas B. Wilson, *President.*

William O'Hanlon, *Secretary and Treasurer.*

STATION STAFF.

Whitman H. Jordan, ScD., LL.D., *Director.*

George W. Churchill, *Agriculturist and Superintendent of Labor.*
William P. Wheeler, *First Assistant (Animal Industry).*
Fred C. Stewart, M.S., *Botanist.*
John G. Grossenbacher, Ph.B., A.B., *Associate Botanist.*
G. Talbot French, B.S.,
[1] Stockton M. McMurran, B.S., *Assistant Botanists.*
Lucius L. Van Slyke, Ph.D., *Chemist.*
Alfred W. Bosworth, B.S.,
Ernest L. Baker, B.S., *Associate Chemists.*
Arthur W. Clark, B.S.,
[2] Anton R. Rose, B.S.,
Morgan P. Sweeney, A.M.,
[3] James T. Cusick, B.S.,
Otto McCreary, B.S., *Assistant Chemists.*
Harry A. Harding, Ph.D., *Bacteriologist.*
[4] Martin J. Prucha, M.S., *Associate Bacteriologist.*
James K. Wilson, B.S., *Assistant Bacteriologist.*
George A. Smith, *Dairy Expert.*
Frank H. Hall, B.S., *Editor and Librarian.*
Percival J. Parrott, M.A., *Entomologist.*
Harold E. Hodgkiss, B.S.,
William J. Schoene, M.S., *Assistant Entomologists.*
Ulysses P. Hedrick, M.S., *Horticulturist.*
[5] W. H. Alderman, B.S.Agr., *Associate Horticulturist.*
[3] Richard Wellington, B.S.,
[2] Maxwell J. Dorsey, M.S.,
[6] George H. Howe, B.S.A., *Assistant Horticulturists.*
Orrin M. Taylor, *Foreman in Horticulture.*
[7] F. Atwood Sirrine, M.S., *Special Agent.*
[8] Jennie Terwilliger, *Director's Secretary.*
Frank E. Newton,
Willard F. Patchin,
Lena G. Curtis,
[9] May A. Durkin,
[10] Agnes E. Ryan, *Clerks and Stenographers.*
Adin H. Horton, *Computer and Mailing Clerk.*
[11] Fred Z. Hartzell, M.A., *Assistant Entomologist.*
[11] Fred E. Gladwin, B.S., *Special Agent.*

Address all correspondence, not to individual members of the staff, but to the New York Agricultural Experiment Station, Geneva, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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[1] Resigned Nov. 30.
[2] Resigned Sept. 30.
[3] Absent on leave after Oct. 31.
[4] Absent on leave after Sept. 30.
[5] Assistant Horticulturist to July 31.
[6] Appointed Nov. 1.
[7] Riverhead (L. I.), N. Y.
[8] Absent on leave.
[9] Resigned June 1.
[10] Appointed July 11.
[11] Connected with Chautauqua Grape Investigations.

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Twenty-Ninth Annual Report

OF THE

New York Agricultural Experiment Station

TREASURER'S REPORT.

Geneva, N. Y., *October* 1, 1910.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1910:

Maintenance Fund — Necessary Expense.

APPROPRIATION 1909–1910.

Receipts.

1909.			*Dr.*
Oct.	1.	To balance on hand	$24 78
		To amount received from Comptroller	22,500 00
			$22,524 78

		Expenditures.	*Cr.*
1909.			
Oct.	1.	By building and repairs..........	$1,013 30
		By chemical supplies..............	538 39
		By contingent fund	2,770 03
		By feeding stuffs	1,979 79
		By fertilizers	283 79
		By freight and express	637 58
		By furniture and fixtures..........	51 38
		By heat, light and water...........	1,185 85
		By library	1,136 14
		By live stock	5 00
		By postage and stationery..........	1,516 69
		By publications	2,603 26
		By scientific apparatus	82 91
		By seeds, plants and sundry supplies.	2,782 80
		By tools, implements and machinery.	1,196 07
		By traveling expenses	2,307 39
1910.			
Oct.	1.	By balance	2,434 41
			$22,524 78

GENERAL EXPENSE — HEAT, LIGHT, WATER, ETC.

APPROPRIATION 1909–1910.

Receipts.

			Dr.
1909.			
Oct.	1.	To balance on hand...............	$34 62
		To amount received from Comptroller	5,500 00
			$5,534 62

		Expenditures.	*Cr.*
		By building and repairs...........	$2,855 19
		By heat, light and water..........	2,551 13
		By tools, implements and machinery.	75 74
1910.			
Oct.	1.	By balance	52 56
			$5,534 62

SPECIAL FUND — HORTICULTURAL INVESTIGATIONS.

APPROPRIATION 1909–1910.

Receipts.

			Dr.
1909.			
Oct.	1.	To balance on hand	$378 67

		Expenditures.	*Cr.*
		By salaries	$360 40
1910.			
Oct.	1.	By balance	18 27
			378 67

SALARIES.

Receipts.

1909.			*Dr.*
Oct.	1.	To balance on hand	$269 40
		To amount received from Comptroller	40,000 00
			$40,269 40

Expenditures.

			Cr.
		By salaries	$37,927 59
1910.			
Oct.	1.	By balance	2,341 81
			$40,269 40

LABOR.

Receipts.

1909.			*Dr.*
Oct.	1.	To balance on hand....	$262 34
		To amount received from Comptroller	15,000 00
			$15,262 34

Expenditures.

			Cr.
		By labor	$14,601 16
1910.			
Oct.	1.	By balance	661 18
			$15,262 34

FERTILIZER INSPECTION.

Receipts.

			Dr.
1909.			
Oct.	1.	To balance on hand	$1,562 30
		To amount received from Comptroller	8,500 00
		To amount due from Comptroller	246 35
			$10,308 65

Expenditures.

			Cr.
		By chemical supplies	$114 81
		By contingent expenses	2 50
		By freight and express	39 90
		By heat, light and water	354 80
		By postage and stationery	2 44
		By publications	1,251 23
		By salaries	8,186 40
		By scientific apparatus	140 46
		By traveling expenses	207 95
1910.			
Oct.	1.	By balance	8 16
			$10,308 65

CONCENTRATED FEEDING STUFF INSPECTION.

Receipts.

			Dr.
1909.			
Oct.	1.	To balance on hand	$685 25
		To amount received from Comptroller	3,500 00
			4,185 25

		Expenditures.	Cr.
1909.			
Oct.	1.	By chemical supplies..............	$50 50
		By contingent expenses.............	75
		By freight and express.............	54 56
		By heat, light and water............	72 40
		By postage and stationery..........	35
		By publications....................	1,291 40
		By salaries........................	2,273 96
		By seeds, plants and sundry supplies..	61
		By traveling expenses..............	54 28
1910.			
Oct.	1.	By balance	386 44
			$4,185 25

CHAUTAUQUA GRAPE WORK.

Receipts.	Dr.
To amount received from Comptroller.	$5,151 69

Expenditures.	Cr.
By building and repairs............	$593 86
By chemical supplies..............	20 58
By contingent expenses.............	556 29
By fertilizers	95 01
By freight and express.............	9 83
By labor	319 53
By postage and stationery..........	21 04
By salaries	2,536 69
By scientific apparatus............	97 04
By seeds, plants and sundry supplies..	591 97
By traveling expenses..............	309 85
	$5,151 69

UNITED STATES APPROPRIATIONS 1909–1910.

HATCH FUND.

Receipts.	*Dr*
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1910, under act of Congress approved March 2, 1887	$1,500 00

Expenditures.	*Cr.*
By salaries	$756 68
By labor	729 07
By chemical supplies	14 25
	$1,500 00

ADAMS FUND.

Receipts.	*Dr.*
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1910, under act of Congress approved March 16, 1906	$1,300 00

Expenditures.	*Cr.*
By salaries	$1,300 00

Insurance Money.

Receipts.

		Dr.
1909		
Oct.	1. To balance on hand	$22 07

Expenditures.

1910.		*Cr.*
Oct. 1.	By balance	$22 07

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

(Signed) W. O'HANLON,
Treasurer.

DIRECTOR'S REPORT.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

GENTLEMEN.— I have the honor to present herewith a report for the year 1910 of the institution under your care. This report includes the main administrative details, reviews of the bulletins published during the year which give in detail an account of the investigations that are more or less complete, a summary of the results that are most important to farm practice and a statement of the needs of the institution.

ADMINISTRATION.

STATION STAFF.

The number of persons in the staff who are giving expert service in conducting experiments and investigations is now thirty. The number of helpers in the various departments, including stenographers, engineer, janitors and foreman, is twelve, while the common laborers vary from twenty to twenty-five. The scientific staff is divided among the several departments as follows: Animal husbandry and farm 3, Bacteriology 3, Botany 4, Chemistry 8, Entomology 4, Horticulture 5, library and editorial work 1, special agents 2. The large number of chemists is made necessary by analyses of not less than 1,200 samples of fertilizers, feeds and other commercial articles each year. The clerical and stenographic staff numbers 4, and the engineer, janitors and foreman make up 8 more persons. This apparently large number of helpers is made necessary by the endless and time-consuming detail involved in experimental work, as, for instance, the Horticultural Department has under its care not less than 10,000 varieties of fruit.

A few changes have occurred in the staff during the year.

Anton R. Rose, connected with the Station since February 1, 1906, as Assistant Chemist, resigned to take up further study at Columbia University.

*A reprint of Bulletin No. 332.

Maxwell J. Dorsey, who began his work at the Station in June, 1907, as assistant horticulturist, has resigned to pursue an extended course of study at Cornell University.

One appointment has been made:

George H. Howe, B. S. A., a graduate of the University of Vermont, has been appointed assistant horticulturist and began his duties on November 11.

MAINTENANCE FUNDS.

The legislative appropriations granted for the maintenance of the Station for the fiscal year beginning October 1, 1910, were as follows:

Salaries	$47,000
Labor	15,800
Maintenance and publication of the work of the Station departments	22,500
General expense, heat, light, water, repairs, etc.	5,500
Total	$90,800
Expense of chemical work in analyzing samples of fertilizers and feeds submitted as required by law by the Commissioner of Agriculture:	
Fertilizer inspection	$10,000
Feeding stuffs inspection	3,500
Total	$13,500
For investigating the conditions affecting the grape industry in Chautauqua County (available in June, 1910)	$7,500

It was unanimously agreed by your Board that the following appropriations should be asked of the Legislature of 1911 for the maintenance of the work of the Station during the fiscal year beginning October 1, 1911.

For salaries (resident scientific and clerical staff)	$56,000
For labor	17,000
Maintenance and publication of the work of the various Station departments	26,500
General expense, heat, light, water, repairs, etc.	5,500
For conducting grape investigations in Chautauqua County (salaries and expenses, including bulletins)	7,500
Expense of chemical analysis of samples of fertilizers and feeds submitted as required by law by the Commissioner of Agriculture:	
Fertilizer inspection	$10,000
Feeding stuffs inspection	3,500

It will be noted that larger sums are requested for maintaining the work of the Station during the coming fiscal-year than are available during the present one. The uses to which these additional sums are to be applied, if granted, are stated under a discussion of the needs of the Station.

STATION PUBLICATIONS.

The publications of the Station consist of the so-called complete bulletins which present in detail the methods and data of the experiments and investigations conducted, popular bulletins which are a translation of the complete bulletins into a condensed and popular form, technical bulletins, which are technically scientific, and the annual report. The popular bulletins are the ones that are given a wide distribution, the complete form is mailed on request and those strictly technical are sent mainly to those persons who are engaged in scientific investigation in similar institutions. The annual report, which is made up mostly of the complete bulletins and such special parts as The Apples of New York, is exchanged for similar reports or bulletins from other experiment stations and is mailed to residents of this State up to the limit of the supply.

The number of names on the Station mailing list at the present time is as follows:

POPULAR BULLETINS.

Residents of New York	38,407
Residents of other States	2,751
Newspapers	780
Experiment stations and their staffs	1,485
Miscellaneous	100
Total	43,523

COMPLETE BULLETINS.

Experiment stations and their staffs	1,485
Libraries, scientists, etc	205
Foreign list	278
Individuals	3,845
Miscellaneous	100
Total	5,913

The third in the series of fruit publications, "The Plums of New York," constitutes Part II of the Annual Report for this year. "The Apples of New York" was published as part of the Report for 1903 and "The Grapes of New York" as part of the Report for 1907. There has been a lively nation-wide demand for these publications that is by no means yet satisfied, and which the number of copies printed will not meet. Unfortunately, many volumes of these works have found their way into second-hand book stores and are sold at from five to six dollars for the "Apples" and five dollars for the "Grapes." Private individuals and not the State are thus getting financial gain from what was prepared and printed at public expense. It would seem wise to arrange to distribute these expensive and really valuable publications in such a manner as to insure their being placed in the hands of those persons, fruit growers, teachers and others, for whom they are intended, and it would seem equally wise, in view of the limited editions, to make provision for selling these books at cost price to parties out of the State, exchanges with institutions and state departments being permitted.

THE NEEDS OF THE STATION.

When an educational institution ceases to grow, there is room for reasonable doubt as to whether it is sufficiently responsive to new opportunities for service. This is especially true of an institution which has the agricultural people for its constituency, in view of the rapidly increasing demands that farmers are making upon all the public agencies established for their benefit. Farm practice is more and more insistently asking that science solve its problems and direct its methods. This means that the agricultural college and experiment station must develop their equipment somewhat in proportion to the work they are called upon to do or else be constantly forced to confess their inadequacy to cope with the situation that is thrust upon them.

In applying these general statements to the New York Agricultural Experiment Station it is fair to claim that at no time has

this institution been in a condition of stagnation. Its growth has been steady but very conservative, probably too conservative. During the past fourteen years the average yearly increase of expenditure for maintenance has not been over $3,500. During its entire twenty-eight years of existence the entire expenditure for construction of buildings has been less than $160,000, a sum scarcely more than the initial expense for buildings now granted to newly established agricultural institutions.

The Station now has certain well recognized needs, which should be met if it is to keep pace with its opportunities for service. These are in part, (1) an enlargement of its demonstration work in various parts of the State, (2) more land, (3) an administration and demonstration building.

Demonstration work.— The term "Demonstration" as used in this connection should be clearly defined. It is not intended to mean here the extension of well established agricultural knowledge through illustrative experiments in the field, orchard and garden. That is a method of instruction adopted by agricultural colleges that maintain departments of extension teaching. The function of the experiment station is to enlarge the field of knowledge rather than teach what is already known. The term "demonstration" when applied to the activities of an experiment station should mean, and is here intended to mean, the determination of the applicability and economic value of new methods or modification of old methods, new varieties of field crops and fruits, schemes for maintaining fertility, new spraying liquids and so on through the enlarging and more or less untried processes and materials that are suggested by the investigations carried on at this and similar institutions in other states. The study of an agricultural problem involves both the study of fundamental facts, such as the life history and characteristics of new fungi and insects, the principles of fertility or of animal nutrition, and the adjustment of these facts to practice, an adjustment which generally must be sought in practical experiments. This does not mean that such practical experiments should be carried on in an unending series or in every

locality in the State. When the Station once demonstrates under a sufficient variety of conditions that the lime-sulphur solution will destroy the San José scale and that some other preparation will not do this, there is no reason, so far as the Station is concerned, why it should repeat this work in every fruit county in the State. Many facts demonstrated in one place hold good for all places. The Station's duty is done when it has distributed this information freely to its constituents and it should then pass to new problems that are waiting. There is little to commend in the assumption that knowledge should be injected into farmers without effort on their part and there is little hope, even if the injecting process is attempted, that farmers who refuse to grasp and utilize valuable information that is within their reach will ever become inspiring examples of success. One of the most absurd propositions of the day is that success can be imposed on farmers any more than on men engaged in professional or commercial vocations. The fact that hundreds of farmers and fruit growers have sought for information and utilized it is evidence of what progressive men may do. Nevertheless, much demonstration work of the right sort should be carried on, and this must be accomplished in those localities where the opportunity offers. Orchard demonstration must go where there are orchards and the control of onion smut must be studied where onions are grown. This way of accomplishing its work, viz., by itinerant experiments according to opportunity, is the policy of the Station. The Station has already done much work of this kind. During the last three years 141 experiments, mostly coöperative, have been carried on in 35 counties, 84 townships and on the premises of 108 farmers. So varied, however, are the agricultural interests and so numerous are the problems that much more of the same kind of work could have been done with profit, and it is to enlarge this phase of its activities that your Board of Control asks the Legislature to add $14,200 to its maintenance funds.

In order to show the extent of this work in various parts of the State, the following summaries have been prepared:

GEOGRAPHICAL DISTRIBUTION OF STATION EXPERIMENTS OUTSIDE ITS OWN FARM.

Counties	Localities	Farms	Experi-ments	Counties	Localities	Farms	Experi-ments
Allegany......	Alfred..........	1	1	Monroe......	South Greece....	1	1
	Andover.........	3	3	Nassau.......	Glenhead.......	1	3
	Black Creek....	1	1	Niagara......	Lockport.......	3	5
	Ceres..........	2	2		Youngstown....	2	2
	Fillmore........	1	1	Onondaga....	Baldwinsville...	1	1
	Scio...........	1	1		East Syracuse...	1	2
Cattaraugus...	Salamanca......	1	1		Fayetteville.....	1	1
Cayuga.......	Ensenore.......	1	1		South Onondaga.	1	1
	Martville.......	1	1	Ontario......	Canandaigua....	1	1
	Sterling Station.	1	3		Geneva.........	1	3
Chautauqua...	Brocton........	1	1		Phelps.........	1	1
	Fredonia.......	2	2		Seneca Castle...	4	5
	Prospect Station.	1	1		Seneca.........	1	1
	Ripley.........	1	1		Shortsville......	1	1
	Silver Creek....	2	2		Stanley........	1	1
	West Irving....	2	2		Victor.........	2	2
	West Sheridan..	1	1	Orleans......	Albion.........	5	5
	Westfield.......	2	2		Carlton.........	2	2
Chemung......	Big Flats.......	1	2		Medina.........	2	2
	Elmira.........	1	3	St. Lawrence..	Ogdensburg.....	1	2
Clinton........	Ellenburg.......	1	1		Winthrop.......	1	1
	Mooers Forks...	1	1	Schuyler.....	Watkins........	1	1
	Plattsburg......	1	2	Seneca.......	Interlaken......	1	1
Columbia......	Kinderhook.....	1	1		Seneca Falls....	1	1
Delaware......	Halcottsville....	1	2	Steuben......	Addison........	2	2
	Davenport......	1	1		Corning........	1	3
Dutchess......	Amenia........	1	1		Hornell........	1	1
Erie..........	Lancaster......	1	1	Suffolk.......	Centerville......	1	1
	Springville......	1	1		Cutchogue......	1	1
	Willink.........	1	1		Jamesport......	1	3
Franklin......	Chateaugay.....	1	3		Peconic........	1	1
	Malone.........	1	2		Riverhead......	1	5
Genesee.......	Batavia........	1	3		Southampton...	2	4
Herkimer......	Frankfort......	1	1	Tompkins....	Groton.........	1	1
Jefferson......	Adams.........	1	1		Ithaca.........	1	1
	Watertown.....	1	1	Ulster........	Marlboro.......	1	1
Livingston.....	Geneseo.......	1	1		Milton.........	2	2
	Greigsville......	1	1	Washington...	Granville.......	1	1
Madison.......	Earlville........	1	1		Greenwich......	1	3
	Solsville........	1	1	Wayne.......	Clyde..........	1	1
	Lebanon.......	1	1	Westchester...	Peekskill.......	1	1
Monroe.......	Brockport......	2	2	Wyoming....	Silver Springs...	1	1
	Hilton.........	1	1	Yates........	Dundee........	1	1

CO-OPERATIVE EXPERIMENTS: KIND, LOCATION AND CO-OPERATOR.

ALFALFA EXPERIMENTS

Silver Springs........ M. J. Barber
Solsville............ A. L. Brigham
Peekskill........... Thos. Brownlie
Malone............. S. H. Child
Hornell............. W. S. Clark
Andover (2 farms)... S. G. Crandall
Alfred.............. S. G. Crandall
Halcottsville........ E. H. Dimmick
Southold........... Dr. H. Emerson
Martville........... H. N. Eno
Springville.......... F. J. Ferrin
Ensenore........... Jas. A. Gould
Lebanon............ L. C. Hatch
Scio................ T. C. Kane
Halcottsville........ G. W. Kelley
Ellenburgh......... A. S. Lewis
Ithaca............. Jas. S. Lyke
Black Creek......... Archie Lyon
Davenport.......... Jas. McAuley
Addison............ W. A. McCarthy
Earlville............ F. A. Miller

CO-OPERATIVE EXPERIMENTS; KIND, LOCATION AND CO-OPERATOR—(Continued).

Salamanca.......... W. F. Niles
Frankfort........... T. B. Nichols
Mooers Forks........ A. F. O'Brien
Amenia............. H. V. D. Reed
Ceres............... H. B. Rice
Dundee............. B. H. Sackett
Watkins............. J. W. Sheppard
Malone............. W. A. Sherwin
Fillmore............ Judson Stickle
Seneca Falls......... F. E. Thompson
Addison............. C. S. Whitmore
Granville........... T. J. Welch
Ceres............... L. C. White
Greigsville.......... C. H. Whitney
Winthrop........... Carlton Wires

POTATO SPRAYING EXPERIMENTS

Riverhead (3 yrs.)... F. A. Sirrine
Willink............. M. J. Buntin
Batavia (3 yrs.)..... G. A. Prole
Elmira (3 yrs.)...... John Strouse
Victor.............. C. E. Green
Interlaken.......... Bradley Bros.
Groton............. E. A. Landon
Sterling Station (3 years)........... A. E. Curtis
East Syracuse (2 yrs.) M. W. Garrett
Ogdensburg (2 yrs.).. A. Tuck
Chateaugay (2 yrs.).. O. Smith & Son
Greenwich (3 yrs.)... P. C. Billings
Glenhead (3 yrs.).... G. T. Powell
Jamesport (3 yrs.)... H. A. Hallock
Southampton (3 yrs.). L. E. Downs
Victor.............. W. C. Green
Plattsburgh (2 yrs.).. Pardy Bros.
Albion............. Ora Lee, Jr.
Andover............ J. M. Greene & Son
Lancaster........... John Engler

CURRANT CANE BLIGHT EXPERIMENTS

Milton (3 years)..... J. R. Clarke

CABBAGE BLACK ROT EXPERIMENTS

Canandaigua........ S. L. Van Voorhis
Seneca Castle (3 yrs.). Levi Page
" " .... Dan'l Delea
" " .... O. M. Winburn

POTATO SCAB EXPERIMENTS

Riverhead.......... F. A. Sirrine

LEAF BLISTER MITE EXPERIMENTS

Victor.. .... E. C. Green
Albion............. Wm. A. Lafler
Seneca............. C. Willard Rice

HESSIAN FLY STUDIES

Adams............. Jason Garlock
Clyde (3 yrs.)....... H. F. Daboll

Corning (3 yrs.)..... G. E. Wolcott
Geneva (3 yrs.)...... Maxwell Bros.
Watertown......... S. R. Cleveland

PEAR PSYLLA EXPERIMENTS

Lockport........... E. Moody & Sons
" .... Mrs. Oliver
Hilton............. Lawrence Wright

FALSE-TARNISHED-BUG CONTROL EXPERIMENTS

Lockport........... D. Dwight McCollum
Lockport........... E. Moody & Sons

GRAPE-INSECT EXPERIMENTS

Westfield........... Louis Bourne
Fredonia........... S. J. Lowell
Prospect Station..... James Barnes
West Irving (2 lines). Charles Secord
West Irving (2 lines). M. J. Sackett
Silver Creek......... Charles Horton
Fredonia........... H. L. Cumming

LIME-SULPHUR EXPERIMENTS

Stanley............ E. D. Palmer
Geneseo............ U. E. Ross & S. Fraser
Milton............. Arthur E. Bell
Youngstown........ S. S. Hopkins
Albion............. Geo. B. LaMont
Albion............. L. R. Rogers
Lockport........... Asa Baldwin
Albion............. B. L. Perkins
Marlborough........ J. A. Hepworth
Brockport.......... H. L. Bulkley
Brockport.......... Bert H. Henion
Shortsville.......... John Q. Wells
Phelps............. F. A. Salisbury
Carlton............. G. D. Simpson
Medina............. A. J. Skinner
Medina............. F. W. Paine
Lockport........... A. H. Earnest

ORCHARD TILLAGE *vs.* SOD MULCH EXPERIMENTS

South Greece (continuous).......... W. D. Auchter
South Onondaga (continuous).......... Grant Hitchings

DWARF APPLE EXPERIMENTS

Carlton (continuous). A. Wood
Fayetteville (continuous)............. F. E. Dawley
Kinderhook (continuous)............. Edw. Van Alstyne

CO-OPERATIVE EXPERIMENTS; KIND, LOCATION AND CO-OPERATOR—(Continued).

GRAPE CULTURE EXPERIMENTS	
Ripley	C. M. Hamilton
Westfield	S. S. Grandin
Silver Creek	Miss Frances Jennings
Brocton	James Lee
West Sheridan	H. G. Miner
POTATO FERTILIZER TESTS	
Cutchogue	W. M. Fogarty
Riverhead	F. A. Sirrine
Centerville	I. W. Young
POTATO VARIETY TESTS	
Riverhead	F. A. Sirrine
TOBACCO FERTILIZER EXPERIMENTS	
Big Flats	J. R. Minier
Baldwinsville	Fred J. Patchett

Additional land.— The original purchase of land for the Experiment Station farm, thirty years ago, was 130 acres more or less. This area has come to be greatly insufficient for the Station's needs. On it are now growing not far from 10,000 varieties of fruits, both large and small, and so far as it can be done it is made to support a herd of nearly forty Jerseys and grade Jerseys, besides several pairs of horses. On four sides the Station is bounded by land none of which can ever come into its possession, at least not for many years. There is available, however, an exceptionally fine field of nearly ninety acres cornering on the northwest corner of the Station property on which are buildings worth not less than $6,000, that can be bought at a very reasonable price. Several years ago this land came into the possession of Hobart College, by which institution it was held until last February. As it had been placed on the market and seemed likely to pass out of the reach of the Station permanently, it was purchased by the Director of the Station, after full consultation with your Board, to be sold to the State, if the Legislature so provides, at the exact cost to the one making the purchase. In view of the character and proximity of this land to the Station to secure it was deemed by all concerned to be wise business foresight. To fail to secure this land for Station uses would be a serious mistake. The Legislature of 1910 made an appropriation for the purchase of this land, but on account of the great excess of appropriations over the State's income the item was disallowed by the Governor.

An administration and demonstration building.— The need of this building has been presented to the Legislature for three successive years. The Legislatures of 1909 and 1910 each authorized

its erection and made an appropriation therefor, but, as with the item for land, the Governor felt obliged to disapprove the outlay because of insufficient funds. The reasons why such a building should be provided have been given several times but are restated below, together with a more recently developed condition that still further emphasizes the need of additional building space:

(1) There is no place at the institution where an audience can be assembled, excepting out of doors in the pleasant days of the warm season. This is wrong; for the work of the Station stands in such relation to educational interests and farm practice that some way of assembling audiences on the Station ground and bringing them into close range with the Station activities and results should be made possible.

(2) It is extremely desirable that space shall be provided where the results of Station work can be illustrated in a concrete form. We have many visitors who state that they come to see what the Station is doing, not realizing that in the progress of our inquiries they can only see a single point in the progress of an experiment or investigation, which to the untrained eye may be meaningless. Space is needed for the objective display of results that have been reached in dairy work, in the study of farm pests, field experiments and in other directions. Such an exhibit would be especially useful and instructive in connection with meetings here of horticultural societies and other bodies interested in special lines of production.

(3) The number of the scientific staff is now such that more office room is needed. This can be provided by removing the museum collections in the building now occupied by the departments of bacteriology, botany, dairying, entomology and horticulture, to the proposed new building.

(4) The building now used for administrative and library purposes is needed for other uses. It has come to be necessary to arrange for boarding the unmarried members of the staff at some point nearer than the city. Rooms are now available on the Station grounds, but arrangements for meals near the Station are now difficult and uncertain, sometimes impossible. With slight expense

the building now used for offices and library could be adapted to the uses indicated and it would be a much needed convenience. Getting a noon lunch a mile or mile and a half away occasions either much loss of time or such haste as is equally detrimental to health and good work.

GRAPE INVESTIGATIONS IN CHAUTAUQUA COUNTY.

This work has been prosecuted during the season of 1910 along two main lines, viz., experiments on the maintenance of the fertility of vineyards and the repression of the ravages of fungous and insect pests. It is evident that whatever misfortunes have befallen the grape growers of Chautauqua county are due to a combination of causes rather than to any single one, and if the studies that have been undertaken are to establish grape growing on a safer and more rational basis they must be inclusive of all the main factors involved. For this reason it has been found necessary to distribute the experimental work quite generally, choosing such locations as offered opportunity for observations of the kind needed. Fertility experiments are now in operation in five places and spraying experiments were undertaken in eight localities. The experience in Chautauqua county well illustrates the fallacy of establishing permanent branch experiment stations with a fixed investment in land, buildings and other equipment. While the Station has permanent headquarters at Fredonia on land that it has leased for a term of years, this is only one place where experimental work is conducted. This locality does not offer opportunity for all the needed observations and never can be made to do so. It is conceivable that in time some other locality or localities will be preferable as headquarters because of new problems or conditions. Itinerancy of effort will always be a necessity, not only for Chautauqua county but for the State, and a flexibility that is adaptable to problems that are constantly changing in kind and location is less expensive and more efficient than the inelastic and expensive plan of definitely located establishments.

Some of the experiments so far undertaken in Chautauqua county will not yield results for several years, but others have

already reached a promising outcome. These are to be reported in bulletins now in preparation. While these results are reached in Chautauqua county, some of them will certainly be of value in all grape-growing districts in the State.

EXPERIMENTS WITH TOBACCO.

Experiments with tobacco are now being carried on at Big Flats and at Baldwinsville in coöperation with the United States Department of Agriculture. The problems being studied are the effect of various fertilizers on the yield and quality of tobacco and the relation of certain rotation of crops to tobacco growing.

THE FUNCTION OF THE STATION AND THE WORK IT CAN DO.

The question of the work the Station should undertake to do is an ever-recurring one. Its primary office, unquestionably, is to establish facts and principles that shall serve as a safe guide for conducting and developing agricultural practice. The effort cannot stop with this, however, It is equally the duty of such an institution to suggest new applications of knowledge, verify conclusions in their relations to agricultural practice, and disseminate the results of its investigations. All this the Station attempts to do. It must be confessed, however, that its efforts are not as closely confined to its real function as is essential to maximum efficiency. There are constant and insistent requests for services that lie outside the purposes for which the Station was founded. It is very certain, however, that the members of the staff cannot successfully carry on important investigations and experiments unless they can give to such work their uninterrupted attention through a large portion of the year, a fact that is not fully appreciated by those without experience in studying scientific problems. For this reason it becomes necessary to decline to perform many of the services that are requested. The following explanations are offered with the hope that they will clear up misunderstandings in several directions.

Addresses.— This is a time of the strenuous exploitation of agricultural knowledge and the agricultural public is demanding that

those connected with agricultural institutions shall be almost constantly acting as popular platform teachers, a service that is undoubtedly productive of great good. The experiences of past years make it clear, however, that because of the continuous demands made on the members of the Station staff for speaking and demonstration work of an educational character, the management of the Station will find it necessary to limit the time and energy that the members of the Station staff shall give to popular teaching. It cannot be truly said that such teaching is more important than the discovery of facts and principles, for indeed there can be no teaching without knowledge and no well-established knowledge without careful and severe inquiry. The members of the Station staff can properly devote but little time to public speaking outside of the larger agricultural conventions and a given amount of institute work. To attempt more than this would destroy their efficiency in the work they are set to do.

Chemical analyses for individuals.— There come to the Station each year numerous requests for services of special kinds, such as the analysis of soil, drinking water, samples of feeds, fertilizers, seeds, milk, vinegar, drugs, mineral substances, stomachs of animals supposed to be poisoned, etc. Many persons evidently suppose that it is the rightful business of the Station to analyze anything that may be sent to it. These persons do not understand that to comply with these requests in an indiscriminate way would largely waste the funds of the Station and the time of its staff. The Station must necessarily hold itself pretty closely to activities that serve the interests of its constituents in a more or less general way.

Commercial chemical analyses.— Manufacturers of fertilizers and feeds, and dealers in the same, often ask for analyses of the products they manufacture or sell. In many cases there is expressed a willingness to pay for the service. The answer to these requests is that the Station does no commercial work and under no conditions whatever can it assume the burden of the chemical or other expert work for the trades.

Analyses of fertilizers and feeds.— Frequently farmers mail us samples of feeds or fertilizers, asking for an analysis. In most cases these are samples of brands that are inspected by the State and it is unwise to duplicate work, especially when samples sent by consumers, because of inexperience in sampling, are very liable not to represent fairly the goods from which they are taken. Users of feeds and fertilizers should utilize the official reports as a guide to the character of these materials. It would be impossible to make special analyses for each farmer in the State, but what is granted in one case cannot rightfully be refused in another.

It is often possible by the mere physical inspection of a sample of feed for us to determine what are the materials out of which it is made. This sort of an examination consumes little time and it can often be made the basis of useful advice to a prospective buyer. Such examinations we are glad to make.

It should be stated, however, that when an association of farmers makes a contract for the purchase of a large lot of feed or fertilizer on the basis of a guaranteed composition, the Station is always willing to make free analyses to determine whether the goods are according to the guarantee. This we have done in many cases. In such cases the samples should be taken in accordance with directions given by the Station. Such analyses must not interfere, however, with the prompt analysis of official samples sent to the Station by the Commissioner of Agriculture.

Seed examinations.— Inquiries are frequently received by us as to the purity of samples of seeds. We are glad to give attention to such inquiries, and our replies often serve to warn the farmers of a community against injurious adulterations, such as dodder and trefoil in alfalfa seed.

Water analyses.— Many samples of drinking water are sent to us that we may determine their sanitary quality. Examinations of this kind are not undertaken by the Station as they properly belong to the State Board of Health, which is located at Albany.

Analysis of soils.— Numerous samples of soil are received at the Station with the request that they be analyzed to determine

the fertilizers that should be used or the crops to which the soils are adapted. The Station does not undertake soil analyses for these purposes because, with our present state of knowledge, it would be practically useless to do it. There is, to be sure, a widely prevailing impression that chemical analysis is competent to detect the causes of lack of fertility in any soil, or even the crops or fruits to which the soil is adapted. In special cases this may be true, but in a general way nothing can be more erroneous. It is possible for us to ascertain exactly what is in a soil and how much, but it is safe to assert that nearly every soil contains enough nitrogen, phosphoric acid and potash to produce a great many crops of any farm plant whatever. The weak point is our inability to determine how much of this is available to the plant, and how rapidly.

The most feasible way of getting the information desired as to profits from commercial fertilizers, is by the experimental use of chemicals and raw materials rather than the mixed fertilizers. For instance, if a soil responds to phosphoric acid and to that alone, the application of an acid phosphate which contains no potash or nitrogen would be the proper thing. If potash only is needed, an application of muriate or sulphate of potash alone would be all that is required. Possibly a combination of nitrogen and phosphoric acid without potash would meet the needs. Perhaps a "complete" fertilizer would be most profitable. Now by applying these various fertilizing substances alone and in mixtures in uch a way as to make comparisons, it is possible to ascertain more definitely than from chemical analysis what ingredients it is profitable to apply. The Station is always ready to suggest plans for simple fertilizer experiments.

Foods and drugs not analyzed.— Under no conditions can the Station undertake analyses of articles coming under the food and drug laws of the State, or of minerals, mineral waters, stomachs of animals supposedly poisoned or other miscellaneous work of a non-agricultural character.

Personal inspection of farms not possible except for the study of specific problems.— Requests are not infrequently received at

the Station to have some member of the staff visit a particular farm or orchard or other agricultural operation in order to give expert advice as to the business management that should be followed. Such requests are made in good faith and with the best of motives and are a gratifying evidence of confidence in the Station, but they show something of a misconception of the kind of aid the institution can render to farmers. The Station staff is not made up of expert farm managers but of scientific specialists who are studying specific problems that are important to agriculture. To illustrate, the botanists study plant diseases and their remedies; the bacteriologists investigate soil and dairy conditions that involve the action of germ life; the entomologists inquire into the life history of injurious insects and the methods for preventing their ravages; the horticulturists deal with such questions as plant breeding, orchard culture, and varieties of fruit, and the chemists and other members of the staff take up questions relating to plant and animal nutrition, dairy methods, barn sanitation and poultry production. All this effort is largely in the direction of seeking new knowledge, which, when obtained, we endeavor to adjust to agricultural practice. We do not endeavor to adjust all knowledge, experience and business conditions to a system for the management of a given farm, for this is the owner's problem and for us to take it out of his hands, even if it were possible, would do him more harm than good. We can and do give advice freely on specific points connected with farm management when the questions involved are definitely brought before us. Members of the Station staff do make many visits to farms and fruit plants when by so doing they are able to prosecute the study of some important problem.

Station literature.— The Station is in almost constant receipt of requests for agricultural literature of the most general kind covering all phases of farm methods and management. Such requests cannot be met to the extent that seems to be expected. An experiment station, endowed for the maintenance of research, cannot wisely act as a bureau of compilation to prepare and publish books or pamphlets on all sorts of agricultural subjects. Its func-

tion is not that of a publishing house, or of the extension department of a college. It is often necessary, to be sure, to do more or less compiling in order to adjust existing information with results obtained at the Station. Such organization of knowledge on a given subject is legitimate to an investigating agency and even necessary. There is a broad difference, however, between an exhaustive treatise on the growing of corn or potatoes or any other crop and a bulletin setting forth the results of an investigation on the stage of growth of corn that yields the most nutritive value, or on the influence of seed selection on the amount and character of the product. When a station has set forth the results of its work in a clear manner and their relation to pre-existing knowledge, accompanied by sufficient demonstration of their practical applications, it has fulfilled its duty to the agricultural public. The Station bulletins are, therefore, practically confined to stating the results of the work of the Station, with such accompanying explanations as seem to be necessary. They are free to all citizens of the State who ask for them.

INVESTIGATION.

DEPARTMENT OF BACTERIOLOGY.

The modern milk pail.— In connection with the Dairy Department the question of a better milk pail has been studied both from the standpoint of the milker using the same and from that of the effect of the form of pail upon the germ content of the milk.

More than one-half of the infection which milk receives during the milking process can be prevented by the use of a covered pail. A covered pail which is less than twelve inches high and is provided with an elliptical opening seven by five inches is practically as convenient for milking as an ordinary pail. Such a cover can be placed upon an ordinary milk pail by any tinsmith at very little expense. Such a covered pail is inexpensive, durable, easily cleaned and one of the most effective in keeping bacteria out of the milk. The details of this study are given in Bulletin 326.

Variation in bacteria.— The limiting factor in the study of many agricultural problems is our ability to recognize and classify quickly the bacteria encountered. The accuracy of such classification turns upon the constancy of the reactions used for this purpose. An extended study of fifty strains of the germ causing the black rot of cabbage showed that the reactions recommended by the Society of American Bacteriologists for classification purposes gave constant results in all cases. This work was published as Technical Bulletin 13.

The fermentation of citric acid in milk.—This problem has been studied in connection with the Chemical Department and the results published as Technical Bulletin 14. This bulletin is reviewed in connection with the work of the Chemical Department.

Alfalfa inoculation soil.— During the past three seasons soil has been furnished to the following number of farmers: 1908, 161; 1909, 208; 1910, 130.

No extended effort has been made to follow up the results of sending out this soil. The falling off in shipment in 1910 was due to efforts made to put farmers in touch with neighbors who could furnish them with the soil. Interest in alfalfa has been growing constantly and practically all Station publications relating to alfalfa are out of print.

DEPARTMENT OF BOTANY.

Potato spraying experiments.— During the season of 1909 the potato spraying experiments begun in 1902 were continued along the same lines as in previous years. The results have been published in Bulletin 323. In the ten-year experiment at Geneva six sprayings increased the yield 49.75 bushels per acre, while three sprayings increased it 38.67 bushels. In the duplicate of this experiment at Riverhead, Long Island, the gain due to six sprayings was 52.5 bushels per acre and to three sprayings 28.67 bushels. In twelve farmers' business experiments, including 203 acres, the average gain due to spraying was 24.4 bushels per acre; the average total expense of spraying, $4.15 per

acre; and the average net profit $9.55 per acre. Twelve volunteer experimenters reported gains averaging 44.4 bushels per acre.

The average results continue to show that spraying is highly profitable when practiced regularly over a period of several years. In the ten-year experiments at Geneva the average gain for eight years from spraying every two weeks has been 102 bushels per acre, and from spraying three times during the season, 78 bushels. At Riverhead, the corresponding gains have been smaller; viz., 54 and 29 bushels respectively. In 88 business experiments made in seven years the average gain due to spraying has been 41.1 bushels per acre and the average net profit from spraying has been $16.77 per acre. In 200 volunteer experiments reported in six years the average gain from spraying has been 52 bushels per acre.

Medullary spots: A contribution to the life history of some cambium miners.— While studying a disease of currants in the Hudson Valley, dark streaks, which appear as spots in cross section, were often found in the canes. It soon became evident that they were due to some miner. The causal insect-larva and its adult or perfect form were finally secured during the past summer. The miner proved to be the early stage of a tiny moth belonging to a group none of the larvæ of which had been found before.

Somewhat similar larvæ were found mining under the bark of both wild and cultivated species of plum and cherry, and some hawthorns. They hibernate under the bark and therefore their adults cannot be obtained until next summer. What seem to be members of this group of miners have been obtained and described before, but their adult forms were not secured and consequently it is impossible to say, as yet, even though they were said to belong among the flies, just where they belong.

The economic relations of these insects may prove of some importance, for the currant miner has been shown to afford entrance to a fungus which is thus enabled to kill gooseberry shoots. Direct injury to currants and gooseberries is probably not very serious and of course the direct injury to plums, cherries, etc., by other cambium miners is no doubt even less, because the mines are

so small when compared to the size of the plants. A fuller account is found in Technical Bulletin 15.

Notes on New York plant diseases, I.— This is the title of Bulletin 328 which contains short notes on about sixty different plant diseases. Some of the most important items are the following: Bitter rot of apples is a rare disease in New York. The powdery mildew attacking apples in New York is *Podosphæra leucotricha.* It is common in nurseries and also occurs occasionally on bearing trees. The Florida San-José-scale fungus has been found on apple trees on Long Island. The beet leaf-spot disease, *Cercospora beticola,* may be transmitted with the seed. Cosmos is attacked by powdery mildew and a serious stem blight caused by *Phomopsis stewartii* Pk. The English hop mold or mildew, *Sphærotheca humuli,* occurred destructively at Waterville in 1909 and at several other points in 1910. The raggedness of horse chestnut and Norway maple leaves is due to late spring frosts. A puzzling case of œdema of pear trees was observed in a nursery storehouse at Rochester. In a nursery at Geneva, trees of the Compass plum were severely injured by the fruit-rot fungus, *Sclerotinia fructigena,* which killed the twigs and produced cankers on the trunks of the trees. In all cases, the fungus entered by way of the blossoms. The Corticium stage of the potato Rhizoctonia has been found on Long Island. Except on Long Island, the Rhizoctonia disease of potatoes is unimportant in New York. It has been shown that spores of the raspberry cane blight fungus, *Leptosphæria coniothyrium,* on pieces of dead raspberry canes lying on the ground, may retain their viability for four years. A new wilt disease of Vinca, caused by a species of Glœosporium, has been observed at Batavia.

CHEMICAL DEPARTMENT.

Fermentation of citric acid in milk.— Milk contains a small amount of citric acid in combination, probably as calcium citrate. When milk sours, this compound is changed, the citric acid being converted largely into acetic acid and carbon dioxide. Of various micro-organisms experimented with, the only one producing this

change was *Bact. lactis aerogenes.* This change occurs also in the process of cheese making before the curd is pressed. For further details see Technical Bulletin 14.

Chemical study of the lime-sulphur wash.— Various proportions of combinations of lime and sulphur and water have been experimented with. It has been found that most economical results are obtained by using 36 pounds of lime (calcium oxide), 80 pounds of high-grade sulphur and 50 gallons of water. There is practically no loss of lime or of sulphur as sediment; very little sediment of any kind is formed and what occurs is very fine. The solution contains nearly all the sulphide sulphur in the form of calcium pentasulphite (CaS_5), which is the most concentrated sulphur compound found in the lime-sulphur wash. The various conditions that produce sediment and cause loss of materials were studied. With formulas used for the preparation of concentrated washes, it is found that considerable amounts of sulphur and calcium are lost as a result of conversion of soluble calcium thiosulphate into insoluble calcium sulphite. This always occurs when the proportion of water to lime and sulphur by weight is much below the ratio of 3:1. Concentrated commercial preparations contain only small amounts of calcium thiosulphate because during the concentration by boiling it is changed into sulphite. Considerable labor has been expended in studying the relation of concentration of solutions to dilution, in order to prepare a system that involves the least possible error and insures a fairly uniform amount of sulphur in each gallon of diluted mixture. The results indicate that the preparation of the lime-sulphur wash has been placed on a basis such that fruit-growers can prepare home-made solutions and obtain uniform results such as they could not under former conditions. The matter of dilution has also been placed upon a more accurate foundation. Full details of these investigations will be found in Bulletin 329.

DAIRY DEPARTMENT.

Importance of the individual cow.— The production and the cost of the food consumed by each cow in the Station herd are given

for the years 1906-8 in Bulletin 322. The best cow produced almost exactly three times as much milk, or more than twice as much butter, on only one-tenth more food. Such wide variations are found in relatively well bred herds and larger variations occur in ordinary herds.

Since the prices of both food and dairy products are largely fixed by others the single avenue of increased profits within the control of the dairyman is that of increased productivity from individual cows. This may be attained by keeping and breeding from the best and eliminating those which are not making a suitable return from the food consumed.

The modern milk pail.— The results of this study are reviewed on page 25 as the study was conducted in connection with the Department of Bacteriology.

DEPARTMENT OF ENTOMOLOGY.

Experiments with home-made concentrated lime-sulphur mixtures.— This bulletin, No. 330, discusses the results of various experiments by the Station and by a number of fruit growers with home-made concentrated solutions in the Station experiments of 1910.

In the Station experiments of 1910 the densities of the clear solution in a large series of preparations varied from 25° to 30° B. The sediment in nine samples that were analyzed ranged in quantities from 2.9 lbs. to 21.4 lbs. per barrel. The cost of materials to make a barrel of concentrate was from $2.07 to $3.05 according to the formula.

The home-made concentrates when used at effective strengths, as determined by hydrometer tests, have given in the Station experiments for the past three years efficient results on the San José scale and blister-mite.

In the volunteer experiments the densities of the mixtures ranged from 22 to 32.9° B. The cost of materials to make a barrel of concentrate was from $2.10 to $3.50. The amounts of clear solution and sediment varied considerably but, in the main, prepa-

rations of satisfactory densities with moderate amounts of sediment were obtained.

Of eleven volunteer experiments on blister-mite there are ten reports of satisfactory results by the use of the home-made concentrate and one report of failure, caused by lateness of application. Of seven experiments on San José scale there are five reports of efficient control and two reports of partial success, due probably to difficulties in spraying large trees or to the use of mixtures of too low densities. The results on scale emphasize the necessity both of thorough spraying and of using diluted mixtures of efficient strengths to obtain uniform results on this pest. There are four reports on codling moth which are inconclusive because of the conditions of the experiments.

Very dilute mixtures of the home-made concentrate have on the whole proven fairly safe to apple foliage. In a number of orchards slight injuries were noticed on the more tender leaves, especially following the spraying after blossoming. These injuries were generally obscured by the new growth in from seven to ten days. Damages of a more serious nature occurred in a few orchards. Dropping of fruit and leaves are noted in one experiment. Nearly all reports note absence of russeting of apples on trees sprayed with home-made concentrate.

The apple and pear membracids.— Technical Bulletin 17 is largely a technical discussion of various species of membracids which deposit their eggs in buds and young wood of apples and pears.

Ceresa taurina Fitch and *Ceresa borealis* Fairm. oviposit in the buds. *Ceresa bubalus* Fabr. and *Stictocephala inermis* Fabr. lay their eggs in the bark of the young wood. The species ovipositing in bark cause characteristic scars.

In rearing a large number of individuals five distinct stages were completed before the appearance of the adult. The nymphs of the species mentioned may be recognized in their different stages principally by the structures of appendages, character of the spinosity of the body and coloration.

The species breeding on apples and pears depend on succulent weeds and plants for the sustenance of the nymphs. The range of host plants is quite extensive.

Egg parasites have been quite common during the past three years. Two species have been bred which are *Polynema striaticorne* Gir. and *Ottys ceresarum* Ashm. These attack all species.

C. bubalus is the more destructive species to apple and pear wood. *S inermis* does not cause injuries of an important nature. The insertion of eggs between the bud scales by *C. taurina* and *C. borealis* appears to have no detrimental influence on the development of the buds.

Clean cultivation to prevent the growth of the hosts of the nymphs is the most practicable and efficient remedy for the prevention of injury by the tree-hoppers.

Studies on grape insects.— This is the first report of the entomological investigations which have been undertaken in the interests of grape growing in Chautauqua county. Original biologic data are presented on the grape-blossom midge (*Contarinia johnsonii* Sling.), the grape root-worm (*Fidia viticida* Walsh), the grapevine flea-beetle (*Haltica chalybea* Illiger) and the rose-chafer (*Macrodactylus subspinosus* Fabr.) and reports are given of the progress of the experiments underway to devise efficient methods of controlling the more destructive species. Attention of growers is especially called to the results of the spraying operations against the leaf hopper, grape fidia and rose-chafer. Tests conducted during 1910 indicated that a combination of arsenate of lead and glucose is an efficient remedy for the rose-chafer and grape fidia. It is the intention to test this promising remedy under varying conditions for several years before making recommendations as to its actual value for these pests. Grape growers are advised to make thorough tests of this mixture in comparison with the sprays commonly employed. The full discussion of this work will be found in Bulletin 331.

Cambium miners.— Investigations were made by the associate botanist of some cambium miners working in gooseberry and other

plants. This work, published as Technical Bulletin 15, is reviewed on p. 27.

INSPECTION WORK.

Feeding stuffs.—As shown in Bulletin 324, the Station analyzed 412 samples of 375 brands for the inspection season of 1910. The work of this year required much more time than hitherto because of the requirement that the ingredients entering into compounded feeds be guaranteed by the maker or dealer and be determined by the Station. The value of his information, however, well justifies the time spent in securing it.

Fertilizers.— The number of brands has been gradually increasing from year to year. Ten years ago less than 500 brands were licensed, while this year 750 brands were analyzed. These analyses are reported in Bulletin 325.

Insecticides and fungicides.— This is the first year in which analyses have been made of a large number of commercial insecticidal and fungicidal preparations. The samples include bordeaux mixture, lead arsenate, copper sulphate, ammonium copper carbonate, paris green, lime-sulphur wash, nicotine preparations, etc. No bulletin reporting these analyses has yet appeared.

Babcock test glassware.— During the year there have been tested in the Dairy Department 9,116 10 per ct. milk-fat bottles, 3,518 cream bottles and 1,628 pipettes intended for use in creameries, cheese factories and other establishments where milk is paid for by its fat content. The unpacking, testing and repacking, usually in small lots, of these pieces of glassware involves no inconsiderable amount of time, energy and care.

PUBLICATIONS ISSUED DURING 1910.

BULLETINS.

No. 322. March. The individual animal as the unit in profitable dairying. G. A. Smith. Pages 16. Popular edition, pages 8.

No. 323. May. Potato spraying experiments in 1909. F. C. Stewart, G. T. French, S. M. McMurran and F. A. Sirrine. Pages 36. Popular edition, pages 8.

No. 324. July. Inspection of feeding stuffs. Pages 91.

No. 325. September. Report of analysis of samples of fertilizers collected by the Commissioner of Agriculture during 1910. Pages 103.

No. 326. December. The modern milk pail. H. A. Harding, J. K. Wilson and G. A. Smith. Pages 34. Plates 4. Popular edition, pages 8.

No. 327. December. Potato fertilizers: Method of application and form of nitrogen. W. H. Jordan and F. A. Sirrine. Pages 22. Popular edition, pages 4.

No. 328. December. Notes on New York plant diseases, I. F. C. Stewart. Pages 101. Plates 18. Popular edition, pages 12.

No. 329. December. Chemical investigation of best conditions for making lime-sulphur wash. L. L. Van Slyke, A. W. Bosworth and C. C. Hedges. Page 46. Plate 1. Popular edition with Bulletin No. 330.

No. 330. December. Experiments with home-made concentrated lime-sulphur mixtures. P. J. Parrott and W. J. Schoene. Pages 33. Popular edition, with Bulletin No. 329, pages 12.

No. 331. December. Preliminary report on grape insects. F. Z. Hartzell. Pages 98. Plates 15, figs. 7. Popular edition pages 16.

No. 332. Director's report for 1910. W. H. Jordan. Pages 28.

TECHNICAL BULLETINS.

No. 13. June. The constancy of certain physiological characters in the classification of bacteria. H. A. Harding. Pages 39, inserts 3.

No. 14. November. The fermentation of citric acid in milk. Alfred W. Bosworth and M. J. Prucha. Pages 6.

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New York Agricultural Experiment Station,
Geneva, N. Y., December 30, 1910.

W. H. JORDAN.

Director.

REPORT

OF THE

Department of Animal Industry.

W. H. Jordan, *Director.*
W. P. Wheeler, *First Assistant.*
Geo. A. Smith, *Dairy Expert.*

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REPORT OF THE DEPARTMENT OF ANIMAL INDUSTRY.

THE INDIVIDUAL ANIMAL AS THE UNIT IN PROFITABLE DAIRYING *

G. A. SMITH.

SUMMARY.

The Station dairy herd is a selected herd, mainly pure blood Jerseys and Jersey grades, averaging about 6,000 lbs. per year of 5.4 per ct. milk. The herd has suffered from the same mishaps as the average farm herd; so that figures showing individual variation between the cows do not exaggerate, if they equal, the differences existing in such herds. The data are reliable, being based on actual, not estimated, weights and tests, made more regularly and carefully than on any but exceptional farms. The best cow in the herd (the same cow) averaged 10,150 lbs. of 4 per ct. milk annually for three years on $58 worth of food; the poorest cow (different ones each year) averaged 3,350 lbs. of 5.85 per ct. milk on $52.40 worth of food. That is, the best cow produced almost exactly three times as much milk or more than twice as much butter, on only one-tenth more food.

If for the poorer half of the herd we had substituted animals equal to those in the better half, it would have increased the yearly Station revenue $237.40 if we had sold milk at current shippers' prices, or $379.90 if we had sold butter fat, with an added expense of only $40, the cost of the extra food consumed by the better cows.

From the data secured from the purchaser of the product of two dairies in the State, one farmer with 8 cows received from them $877 in one year; while the other farmer received only $868 from 22 cows in the same time.

In another locality some dairymen secured an average of 300 lbs. of butter annually from their cows; others as low as 80 lbs.

These facts emphasize the necessity of "weeding out" poor cows if the dairyman is to produce milk at a profit in these and promised future times of high prices for feeds.

*A reprint of Bulletin No. 322.

INTRODUCTION.

According to the last census there were 226,720 farms in the State of New York and 196,362 of these, or 87 per ct., report the sale of dairy products. The hay crop leads as a farm revenue producer; but with this exception, the sale of the dairy products from the 1,500,000 cows on these farms brought in a larger income than any other source on New York State farms. Accordingly, economy in dairy production is of prime importance in the agriculture of this State. With the continued rise in the price of feeding materials there is an increased need of careful attention to the cost of production if dairying is to be a financial success. This publication calls attention to the wide range in the cost of production among the members of a relatively well-bred herd and emphasizes the fact that the productivity of the individual cow is the true basis for increasing or even keeping up the value of a herd.

In using the data from the Station herd to emphasize the importance of this subject the criticism is met that the conditions are not the same at the Station as on the average farm. The conditions are different in two important particulars; but both of these strengthen rather than lessen the force of the figures: (1) The Station herd has been bred for ten years in a single direction and the individuals do not show as wide a range of variation as would be met among the cows on the average farm; (2) the facts regarding the cost of food consumed and the amount of product returned by each animal are known much more exactly than could be expected on the average farm. It is also true that the Station does not have a range of cheap land for pasture and this lack is supplied by soiling. While this lack of pasture may affect the cost of production it does not markedly influence the comparison of the relative value of the various cows in the herd.

This herd is strictly comparable to the average dairy in that it has suffered from all of the mishaps to which dairies are exposed. In 1900 more than one-half the cows were found to be tuberculous; but by the application of the Bang method, as explained in Bulletin 277, the herd was freed from this disease, and for five years has

not contained a tuberculous animal. It has also suffered from contagious abortion, udder troubles and in some cases from sterility.

In presenting the results with this herd the data summarized begin with 1906 because part of the records of food consumed and milk produced were burned with the Station barns in 1904 and facilities were not at hand for keeping such records for a considerable period following the fire. All cows are included for which we have records covering a complete period of lactation.

THE STATION HERD.

The present Station herd dates from about 1898. At that time it contained the descendants of the animals previously used in an extensive breed test (see Bulletin 21). Because of the expense of maintaining several breeds and because the type of experimental work contemplated would be best served by a fairly uniform herd, a Jersey sire was placed at the head of the herd and some Jersey cows added. A few cows of various breeds have been purchased since to be used in special experiments; but only in one case was the animal added to the herd at the end of the tests.

The principal facts regarding the breeding of the 27 animals whose record is given in this publication are shown in Table I.

The dam of the "Millie" family was Millie Darling, one of the tuberculous cows. She was a large cow weighing about 1,050 pounds and was a very good animal. All of her heifers have proved good producers.

Millie D has had two heifers. The first one lost her first calf and would not breed after that, the second one is not in milk yet. Millie G has had four heifers; we lost the first one when a calf, the second one is just in milk and is doing very well, and two younger ones are not in milk.

Millie F, one heifer, fresh January 14, 1909, and has made a record of 5,721 pounds of milk testing 6 per ct.

Dotshome Carey weighs over 1,000 pounds. We have two of her daughters producing and one not in milk.

Carey of the Station has three daughters, the oldest just in milk and promising. Carey's Fairy has one heifer not yet fresh.

Mabel of Springbrook, the dam of the "Mabels," was a large, strong cow and a good producer, making over 6,000 pounds of milk testing 5.2 per ct. The first heifer we had from her was exceptionally fine, but we had the misfortune to lose her with septic poisoning. The second heifer was a large, strong animal, but not a large producer and has been dropped from the herd. The younger one of her daughters has also been disposed of.

Princess Aurora is a descendant of Barbara Allen, one of the breed test cows described in Bulletin No. 21 of this Station. She had a good record. Her daughter, Aurora, the dam of Princess, was one of the tuberculous herd. She has had three daughters; the oldest one did not prove to be a satisfactory producer, the second one died when a calf, and the younger one, fresh the past year, is not giving a large amount of milk, but it is quite rich. Nettie of the Station was another daughter of Aurora; she gave us a large production as a two-year old but would not breed later.

Belle of the Station was a daughter of Belle of Springbrook and proved an especially good producer but failed to breed and finally had to be dropped. Hammond is said to be a full blood, but was purchased at a sale and we have no papers showing her breeding. We have two heifers from her, the one reported and another just in milk that promises to be fully as good. Satie, the Jersey-Holstein grade, is a large, strong cow. She has been a large producer and her progeny have all proved good. Gertie, the first heifer, has given a large yield and has three daughters, all good, the youngest in milk this year. Marchia, another daughter, gave a good record as a two-year-old, but had the misfortune to lose her second calf, ran down in condition and was killed. Ruth, another daughter, shows a good record, as does her daughter.

Dolly, the Shorthorn-Jersey grade, has been a great producer, but we have only one heifer from her of any value. Bess is a daughter of one of the tuberculous herd. She is a Holstein-Jersey grade, had trouble with her udder and was disposed of. Fannie was a Jersey grade, did not get any heifers, lost part of her udder and was disposed of. Nancy was a Holstein grade, had only one daughter which lost her calf and was a failure.

Table I.—Age, Parentage and Freshening of Cows in Station Herd.

	Born.	Dam.	Sire.	First calf.
Millie D of the Station, No. 176899*	3/16/02	Millie Darling, 87835	D. Leo Mahkenac, 46695	March, 1904
Millie of Geneva, No. 177185	5/24/03	Millie Darling, 87835	Golden Gem Rioter, 64080	May, 1905
Millie Fancy, No. 185158	7/ 8/04	Millie Darling, 87835	King's St. Lambert Fancy, 64050	Aug., 1906
Dotshome Carey, No. 176896	12/21/00	Queen's Carey, 124033	Czar of River Meadow, 51936	Feb., 1903
Carey of the Station, No. 177184	2/10/03	Dotshome Carey, 177184	Prince of Astoria, 50016	March, 1905
Carey Fairy, No. 202916	5/12/06	Dotshome Carey, 177184	King's St. Lambert Fancy, 64050	July, 1908
Mabel of Geneva, No. 177186	5/30/03	Mabel of Springbrook, 112904	Golden Gem Rioter, 64080	July 18, 1905
Mabel of Geneva 2, No. 202915	7/18/05	Mabel of Geneva, 177186	King's St. Lambert Fancy, 64050	April, 1907
Mabel of Geneva 3, No. 202917	8/ 9/06	Mabel of Geneva, 177186	King's St. Lambert Fancy, 64050	Nov., 1908
Princess Aurora, No. 178233	10/23/02	Aurora of the Station 2, 178232	Prince of Astoria, 50016	Jan., 1905
Nettie of the Station 2d, No. 185157	4/ 8/04	Nettie of the Station, 185155	King's St. Lambert Fancy, 64050	July 24, 1906
Belle of the Station, No. 176898	12/31/00	Belle of Springbrook, 121286	Czar of River Meadow, 51936	June 5, 1903
Hammond No. 2	1899	Do not know breeding. Said to be	full blood, purchased at sale in 1903.	
Hammond Fancy	5/15/06	Hammond No. 2	King's St. Lambert Fancy, 64050	June, 1908
Satie	Dec., 1908	Grade Jersey	Holstein	Jan., 1901
Gertie	Jan., 1901	Satie	Queen's Czar	Feb., 1903
Anna G	April, 1904	Gertie	King's St. Lambert Fancy	May, 1906
Gertie F 1	April, 1905	Gertie	King's St. Lambert Fancy	April, 1907
Gertie F 2	May, 1906	Gertie	King's St. Lambert Fancy	April, 1908
Marchia	Mar. 17, 1904	Satie	King's St. Lambert Fancy	April, 1906
Ruth	Jan., 1903	Satie	Prince of Astoria	March, 1905
Ruth F	March, 1906	Ruth	King's St. Lambert Fancy	Feb., 1908
Dolly	Dec., 1897	Short Horn	Jersey Grade	....
Nora D	May, 1903	Dolly	Golden Gem Rioter, 64080	July, 1905
Bess	May, 1903	Chloe	Golden Gem Rioter, 64080	May, 1905
Fannie	Jan., 1901	Duffy Cow	Queen's Czar, 55573	Jan., 1903
Nancy	Bought for feeding experiment, 1904; five years old.			

* Numbers are those on the register of the American Jersey Cattle Club.

FEEDING.

As has been noted, the lack of pasture land made it necessary to feed the cows during the entire year. The grain ration was kept within moderate limits, never going over eight pounds with the best cows in full flow of milk and usually consisting of a small amount of wheat bran when they were not giving milk. The aim was to keep the animals in good condition but not to force them to phenomenal records.

Kind of feed.— The roughage consisted of corn silage and alfalfa, supplemented to some extent by mixed hays, oats and peas, and sugar beets, grown on the Station farm. The grain, which was practically all purchased, was fed in mixtures as given on page 43.

Basis of computing cost.— The cost, as given in this Bulletin, includes only the cost of the food consumed and does not include the expense of feeding and caring for the cows, manufacturing or transporting the product, nor the interest on the money invested; all items which must be considered in computing the final profit or loss in the dairy business. The cost of the grains could be accurately ascertained as they were purchased and have been charged at their cost in the market. As they were obtained at carload prices for the most part, their cost is slightly under what many farmers actually paid for them. The roughage was figured at a price sufficiently liberal to cover the cost of raising and harvesting in average seasons. Hay was figured at $10, corn silage and green food each at $3, and sugar beets at $4 per ton. The small amount of pasture which was available was on valuable land but furnished only a small amount of the food of the cows and was charged at $2 per season. The prices of the grains varied each year and are as follows:

In 1905 wheat bran cost $17, gluten feed $24, cottonseed meal $28, corn meal $22, dried distillers' grains $27 a ton, and oats 36 cents a bushel. In 1906 wheat bran cost $22.50, gluten feed $28, cottonseed meal $29, malt sprouts $18 a ton; oats 40 cents, and corn 56 cents a bushel. In 1907 wheat bran cost $22, gluten feed $29, cottonseed meal $29.70, malt sprouts $18.50 a ton; oats 40 cents, and corn 54 cents a bushel. In 1908 wheat bran cost $23.50, gluten feed $31, cottonseed meal $33, dried distillers'

grains $31 a ton; oats 50 cents, and corn 75 cents a bushel. In 1909 wheat bran cost $23.75, wheat middlings $26.75, gluten feed $32, dried distillers' grains $32, cottonseed meal $33.50, corn meal $28 a ton; oats 50 cents a bushel.

Manner of feeding.— Beginning in the fall the cows were fed thirty-five to fifty pounds of silage a day, the amount varying with the productivity of the cow. This was fed night and morning after milking. About five pounds of hay was fed at noon. About January first one feeding of silage was replaced by sugar beets and this continued two and a half to three months, depending on the supply. The sugar beets were a by-product of an experiment in breeding beets for seed and the supply varied considerably in amount in different years. In May or June, when the alfalfa had attained a height of about one foot it was cut and fed green in place of the silage, the latter being covered and kept for use later in the season. During the past two dry seasons the silage has been an important factor in maintaining a flow of milk during August. Some oats and peas have been grown to supplement the alfalfa.

The grains have been fed in mixtures, the composition of which has varied, depending on the market price of the various grains. The amounts fed have varied with the productivity of the cow, cows in milk receiving from two to eight pounds. The composition of the mixtures used is given below:

AMOUNT AND KIND OF GRAIN USED IN MIXTURE.

1905	Wheat bran	400	lbs.
	Gluten feed	200	"
	Dried distillers' grains	100	"
	Corn meal	100	"
1906	Wheat bran	400	"
	Gluten feed	200	"
	Malt sprouts	100	"
	Cottonseed meal	100	"
	Corn meal	50	"
1907	Wheat bran	400	"
	Gluten feed	200	"
	Malt sprouts	100	"
	Cottonseed meal	100	lbs.
	Corn meal	50	"
1908	Wheat bran	400	"
	Gluten feed	200	"
	Dried distillers' grains	150	"
	Cottonseed meal	100	"
	Corn meal	100	"
1909	Wheat bran	200	"
	Wheat middlings	150	"
	Gluten feed	200	"
	Dried distillers' grains	100	"
	Cottonseed meal	75	"
	Corn meal	100	"

Amount of food consumed.— In this computation the interval covered in each case is that from the beginning of one lactation period until the beginning of the following lactation period and agrees only approximately with the calendar year. The amounts of food consumed by each animal are given in Table II.

TABLE II.—YEARLY AMOUNTS OF FOOD EATEN BY COWS IN STATION HERD.

	Year.	Grain.[1]	Bran.[2]	Silage.[3]	Beets.[4]	Hay.[5]	Green food.[6]
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Millie D.	1906	2,360	......	5,210	2,355	1,020	3,815
	1907	1,786	372	6,716	1,760	980	4,870
	1908	2,844	......	12,130	1,350	730	1,750
Millie Fancy	1906	2,302	......	7,940	1,760	965	3,145
	1907	1,920	180	8,940	1,512	1,055	3,000
	1908	2,228	120	10,445	1,905	1,540	1,500
Millie of G.	1906	2,284	240	6,695	720	910	4,270
	1907	2,360	......	8,900	2,067	1,020	3,850
	1908	1,756	312	11,765	955	1,020	3,400
Dot's Carey	1906	1,850	......	6,275	1,050	985	5,400
	1907	1,928	......	6,155	1,275	1,130	5,400
	1908	1,926	124	7,280	1,450	1,140	5,200
Carey of S.	1906	1,606	177	8,607	1,620	1,351	2,400
	1907	1,572	386	6,750	1,101	1,243	4,370
	1908	1,608	242	10,235	1,433	880	2,100
Carey's Fancy	1908	1,902	200	7,200	1,800	1,055	4,080
Mabel of Geneva	1906	2,068	100	7,493	1,170	1,365	2,145
	1907	2,022	120	6,728	1,346	950	4,400
Mable of G. 2	1907	2,250	......	6,305	1,275	1,600	3,840
	1908	2,212	248	10,260	1,905	1,130	2,250
Mabel of G. 3	1908	1,811	120	9,195	1,905	1,390	1,200
Princess A.	1906	1,783	......	5,340	2,060	1,351	5,460
	1907	1,572	......	7,092	1,080	1,378	3,965
	1908	1,722	260	8,525	1,150	1,500	4,270
Nettie of the Station	1906	2,522	......	9,069	1,503	1,055	2,650
Belle of the Station	1906	2,462	......	7,889	1,756	970	2,920
	1907	2,674	......	5,703	2,150	1,055	5,600
Hammond No. 2	1905	1,936	172	7,520	1,005	1,115	5,125
	1906	2,109	......	8,509	2,528	1,040	2,650
	1907	2,080	200	6,563	1,760	1,055	6,400
	1908	2,223	60	9,239	1,610	1,055	2,600
Hammond F.	1908	2,242	......	8,940	1,610	990	3,600
Satie	1905	1,733	212	8,024	1,005	905	5,260
	1906	2,098	204	8,703	1,682	1,070	2,415
	1907	2,080	200	6,868	1,760	1,055	6,400
	1908	2,038	160	9,048	1,760	1,055	3,050
Gertie	1906	2,192	......	6,756	1,120	910	5,400
	1907	2,722	......	6,876	1,760	980	6,400
Anna G.	1906	1,760	290	8,861	1,048	980	2,920
	1907	1,856	......	5,870	1,340	1,240	5,080
	1908	2,497	80	9,070	1,905	925	3,150
Gertie F. 1	1907	1,748	240	6,010	1,490	1,095	4,400
	1908	1,580	......	8,745	1,490	930	2,600
Gertie F. 2	1908	1,793	178	8,370	1,335	955	2,640
Marchia	1906	1,974	150	8,416	2,308	1,055	2,650
Ruth	1906	2,269	209	6,225	2,644	1,160	1,959
	1907	2,203	286	5,750	1,284	975	4,620
	1908	2,240	238	11,580	1,545	780	1,750
Ruth F.	1908	2,071	100	9,435	960	990	2,700
Dolly	1906	1,973	......	6,608	1,682	1,160	6,400
	1907	2,131	......	8,743	1,760	1,055	3,100
	1908	2,236	......	9,560	1,296	1,005	3,050
Nora	1906	1,722	120	5,598	2,000	1,627	4,130
	1907	1,904	......	8,143	1,620	1,351	4,200
	1908	2,096	138	9,315	1,545	1,915	1,500
Bess	1906	1,966	......	9,308	1,620	1,468	1,320
Fannie	1906	1,930	84	6,520	1,350	905	5,400
	1907	1,780	200	6,691	1,760	975	5,500
Nancy	1906	1,962	300	6,592	1,380	980	5,500
	1907	2,313	200	9,308	1,365	1,165	2,320

[1] Grain is fairly constant for each cow and varies among the cows depending on the flow of milk.
[2] Bran was fed in most cases when cows were dry and varies in amount depending on length of the interval.
[3] Silage was largely increased during 1908 on account of the drought.
[4] Beets are fairly constant, being larger in 1906 on account of the larger supply.
[5] Hay fairly constant.
[6] Green food short in 1908 on account of drought.

TABLE III.— FOOD COST OF MILK FROM STATION HERD, BY INDIVIDUAL COWS.

(Nineteen cows yearly for three years.)

	Year.	Milk.	Fat.	Total fat.	Food cost.	Milk cost per 100 lbs.	Fat cost per pound.
		Lbs.	*Per ct.*	*Lbs.*			
Millie D............	1906	5,821.4	6.07	353.4	$54 85	$0.942	$0.155
	1907	6,456.5	6.23	402.2	53 64	.83	.133
	1908	7,455.7	6.26	467.08	69 35	.933	.148
Millie of G...........	1906	5,247	6.04	317.4	54 38	1.036	.171
	1907	4,765.7	5.94	284.4	53 62	1.125	.188
	1908	6,085.6	5.83	354.9	60 07	.987	.169
Millie F.............	1907	6,536.7	5.3	346.8	52 20	.798	.15
	1908	4,646.4	5.5	255.5	53 93	1.16	.211
	1908–9	8,156.8	5.76	469.9	64 05	.785	.136
Dotshome Carey......	1906	7,009.3	5.34	374.8	49 63	.708	.132
	1907	6,918.7	5.35	370.6	51 58	.745	.139
	1908	5,970.6	5.3	316.2	57 89	.969	.183
Carey of Station......	1906	4,870	6.53	318.4	50 75	1.042	.159
	1907	4,208	6.31	265.8	51 51	1.22	.194
	1908	6,310	6.45	407.2	59 53	.943	.146
Carey Fairy..........	1908	6,541	5.71	373.8	58 75	.8982	.1572
Mabel of Geneva......	1906	3,836.7	5.41	207.9	51 45	1.341	.247
	1907	3,431.8	5.40	185.5	51 96	1.514	.28
Mabel of Geneva 2....	1907	5,533	5.84	323.6	55 88	1.01	.1727
	1908	5,798.9	5.84	338.3	64 34	1.11	.192
Mabel of Geneva 3....	1908	3,007.7	5.50	165.4	55 26	1.838	.3341
Princess Aurora.......	1906	4,187	5.46	228.6	51 36	1.227	.2247
	1907	5,305	5.51	291.6	55 08	1.038	.188
	1908	5,132	5.7	292.8	64 20	1.247	.2193
Nettie of the Station..	1906	7,575.7	5.11	387.7	59 36	.783	.153
Belle of the Station...	1906	8,541.5	5.79	494.8	57 34	.671	.115
	1907	7,583.8	5.88	446.1	61 94	.816	.138
Hammond No. 2......	1905	8,032.9	5.7	458	49 36	.6146	.1078
	1906	7,649.6	5.66	433.2	55 94	.7314	.1291
	1907	7,343.9	5.72	420.4	58 63	.798	.1395
	1908	7,366.2	5.67	417.7	60 08	.8157	.14
Hammond Fancy.....	1908–9	6,391	5.51	352.2	60 36	.944	.1708
Satie................	1905	11,442.6	3.84	439.6	47 57	.4151	.108
	1906	11,596.9	4	470.3	55 85	.4817	.118
	1907	9,795.2	3.94	386.5	58 89	.601	.152
	1908	9,059	4.02	364.4	59 33	.655	.162
Gertie...............	1904	7,244	....	....	....	....	....
	1905	7,177	....	....	....	....	....
	1906	6,557	5.19	340.6	54 42	.83	.16
	1907	10,751	5.3	570.6	64 40	.599	.1128
Anna G............	1906	5,416.4	5.92	311.7	52 16	.963	.163
	1907	3,203	6.05	192.9	50 50	1.578	.2618
	1908	6,920.3	5.89	409.	64 66	.934	.158
Gertie F. No. 1.......	1907	5,521.8	6.23	344.1	51 69	.936	.15
	1908	3,514.4	6.5	228.5	49 84	1.418	.218
Gertie F. No. 2.......	1908	5,429.3	4.77	259.3	53 17	.9795	.205
Marchia.............	1906	5,666	4.98	282.2	55 04	.971	.198
Ruth................	1906	6,643.9	5.07	336.7	56 00	.843	.166
	1907	7,170	4.94	353.5	55 94	.7803	.158
	1908	6,027	5.06	305	63 63	1.056	.208
Ruth F.............	1908	6,118	5.73	351	57 26	.936	.162
Dolly..............	1906	7,844.9	5.74	450.7	55.33	.705	.123
	1907	8,881.2	5.83	517.9	55 39	.62	.106
	1908	7,792.1	6	468.1	60 76	.779	.1298
Nora D............	1906	5,429	5.46	296.7	51.51	.949	.1736
	1907	5,588.1	5.5	310.2	59 06	1.057	.195
	1908	7,136.2	5.4	385.9	69 21	.969	.1793
Bess...............	1906	7,331.9	4.85	346.1	53 09	.724	.153
Fannie.............	1906	6,601	4.98	329.1	52 39	.793	.159
	1907	5,704	4.76	271.6	53 12	.931	.196
Nancy..............	1906	7,106.8	3.96	281.4	55 55	.781	.197
	1907	7,067	3.96	280.6	59 09	.836	.211

THE MILK AND ITS COST.

During each of the three years under consideration there are complete records for nineteen cows, eleven being the same individuals in each of the years while the remainder were either cows which were removed from the herd during the period or heifers which were added.

The money value of the food consumed and the amount of product of each cow is given in Table III.

The pounds of milk, in the above table, were obtained by weighing the milk of each cow separately at each milking during the period of lactation.

In computing the total fat, samples were taken of the morning and evening milk of each cow on three days during each month, and their fat content was determined by the Babcock test. The average of these six samples was used as the fat content of that month and the product of this average and the total milk gave the fat for the month. The total fat was the sum of the monthly fat during the period of lactation. The approximate amount of butter can be estimated by adding one-sixth to the total fat.

The percentage of fat is a theoretical quantity since the actual percentage of fat in the milk varies during the lactation period. That given in the table was obtained by dividing the total fat by the total milk.

The food cost was computed from the food consumed as given in Table II and the prices for the same as stated on page 42.

The cost of the milk and of the fat were obtained by dividing the cost of the food consumed by the yield.

For the purposes of comparison this table may be condensed as follows:

TABLE IV.— FOOD COST OF MILK FROM STATION HERD. (AVERAGE PER COW.)

YEAR.	Milk.	Fat.	Feed cost.	Milk per 100 pounds.	Milk per quart.	Fat per pound.
	Lbs.	*Lbs.*		*Cents*	*Cents*	*Cents*
1906	6,557	345.3	$54 06	82.10	1.75	15.6
1907	6,408	345.4	55 48	83.66	1.84	16
1908	6,142	353	60 42	98.37	2.09	17.1

This table of averages shows that from 1906 to 1908 the cost of food for this herd increased 11.7 per ct., which means that much added difficulty in making dairying profitable. This does not give a complete picture of the increased cost, since in computing this expense the charge for roughage as given on page 42 has been the same for all of the years, so this increase in cost is solely due to the rise in price of the grain. In actual dairying the increase in price of labor and in living expenses has also increased the cost of production of this part of the ration, but the exact amount of the increase can not be well determined.

From these averages it will be seen that the cost of 100 pounds of milk has increased 19.8 per ct. This increase of 8.1 per ct. in the cost of milk in addition to the 11.7 per ct. increase in the cost of food is due to the fact that in 1908 the average yield of milk was decreased. This came about, in part, from the fact that in the forepart of that season two of the best cows lost one-quarter of the udder, which reduced their yield considerably. Also, one of the two-year-olds that came fresh that year made a very small yield. Then there was the added influence of severe drought and the consequent large shortage of green food. If there had not been a reserve stock of silage to assist in maintaining normal production the showing would have been much worse. It is a very good illustration of what the silo may do for many farmers under like conditions. Quite often the grasses dry up in July and August, and without something to supplement the pasture there is a large shrinkage in milk flow which is difficult to get back, and, if possible to do at all, is expensive. The Station's experience is that the use of the summer silo is the most reliable method of furnishing this succulent food.

DISCUSSION OF RESULTS.

This difference in cost of production of milk through variation in yield can be brought out clearest by using the results obtained with the cow giving the largest amount of milk and the one giving the smallest amount in the Station herd and the cost of the same in each of the three years.

TABLE V.— VARIATION IN COST OF PRODUCTION BY DIFFERENT COWS.

		Cost of—		
		Milk per 100 pounds.	Milk per quart.	Fat per pound.
		Cents.	*Cents.*	*Cents.*
1906	Best cow (Satie)	48.17	1.02	11.8
	Poorest cow (Mabel of G.)	134.1	2.85	24.7
1907	Best cow (Satie)	60.1	1.27	15.2
	Poorest cow (Anna G.)	157.8	3.35	26.1
	One cow (Dolly) made fat for	....	....	10.6
1908	Best cow (Satie)	65.5	1.39	16.2
	Poorest cow (Mabel, 3)	183.8	3.91	33.4
	One cow (Dolly) made fat for	....	....	12.9

This shows a difference of 179 per ct. between the best and the poorest cow in the cost of producing milk in 1906 and about as much in the other years and the difference in the cost of butter fat is over 100 per ct. This is a larger percentage of difference than is possible to be made either in the cost of food or in price of the product.

Another comparison illustrating the effect of yield on net results may be made by taking the production of milk and cost of food of the best nine cows and comparing with that of the nine cows making the poorest yield, using for this the figures of 1908.

TABLE VI.— DIFFERENCE BETWEEN BEST AND POOREST HALVES OF HERD.

	Milk.	Cost of food.	Cost per hundred.	Total fat.	Cost of fat.
	Lbs.		*Cts.*	*Lbs.*	*Cts.*
Best nine cows	7,415	$62 85	85.6	418.1	15
Poorest nine cows	5,453	58 40	117.0	290.1	21

This shows that with the poorest nine cows the average production of milk was 1,962 pounds less, and of butter fat 128 pounds less; while the cost of food was only $4.45 less. The milk cost 31.4 cents more per hundred and the fat cost 6 cents a pound more. Taking the average price reported as being received by farmers the past year as a basis, namely $1.35 for milk and 33 cents for butter fat, the income from each of the best nine cows would be for milk $100.10, or for butter fat, $137.94; while for the poorest nine it would be $73.61 for milk, or $95.73 for butter fat, a difference of $26.49 for milk and $42.21 for butter fat. Taking from this the difference in cost of food of $4.45 and we

have $22.04 in favor of each of the best cows in return from the sale of milk or $37.76 from the sale of butter fat. That is, if we had substituted for the nine poorer cows nine as good as the better half of the herd it would have increased our revenue $237.41 if we has sold milk or $379.89 if we had sold butter fat, with no added expense except $40.05 for food.

Any investor looking up a business proposition would consider this a very satisfactory margin of profit. This also shows that the difference in cost of food for the cow making the smaller production is a minor factor; it is the production of milk and butter fat that counts in the final balance.

It is unlikely that many of the Station cows, here considered, were fed at a loss, for this is already a selected herd, many animals having been discarded for poor production; and the herd average of more than 6,000 pounds is far above the general average. It is not improbable, however, that greater net profit would have been secured by disposing of some of the poorer cows and giving to the remaining ones the additional food and care. The wide variation in such a selected herd of good cows indicates plainly that there must be many cows in many herds whose milk is produced at a loss; and this profitless milk not only makes its producer poorer, but, poured on the market in competition with milk from cows that pay their way, it helps to raise the available supply and reduces the market price to all producers.

DATA FROM OTHER HERDS.

In seeking the reason for the complaint that dairying does not pay, some books containing the record of the account of manufacturers of dairy products with the farmer have been examined. The figures obtained show that the variation in results secured by individual farmers is fully as great as the difference in yield of the individual cows of the Station herd. In one case a farmer with eight cows received an income of $877 in the year. In the same plant, the same year, another farmer keeping twenty-two cows received $868. He had done all the work of caring for and feeding fourteen more cows to get about the same income. Figuring the income on the basis of the cow one man receives $109 as against the other man $39, a difference of $70 a head.

The explanation often given by the man with the small returns per cow is that the other man paid out the extra amount for grain. He probably did feed more grain; but consider all the hay and other coarse food that it took to sustain life in those extra fourteen cows, not counting labor! In another locality some of the farmers secured an average of 300 pounds of butter fat per cow and others in the same time went as low as 80 pounds, a difference in income of $100 for the best against only $26 for the poorer yield. It is impossible by any stretch of imagination to figure a profit for the man keeping a herd of cows returning him only $26 a head. The only conclusion to be reached from the data secured is that a few farmers in every neighborhood have solved the question of profitable dairying by breeding and properly caring for good cows, while large numbers are paying no attention to any of those details and are blaming their lack of success to prices.

GENERAL DISCUSSION.

Of the total number of cows in the State there are a large number of which no record of production is ever kept in any way. This makes it difficult to secure figures that are at all representative of the average yield per cow. The only figures to be obtained that are any guide are aggregates from the whole number of cows as reported by the individual farmer to the manufacturer and the total amount of milk received at manufacturing plants. Figures of this class, which have been obtained from representative creameries, cheese factories and milk stations, kept open the full year, situated in St. Lawrence, Jefferson, Lewis, Oneida and Delaware counties, indicate an average production of about 4,500 pounds.

Reports of prices paid the farmer from the same source show that they have varied between $1.30 and $1.40 per hundred pounds. This would mean an average income of about $60.

Some figures obtained from farmers that keep a record of food cost corroborate the records of Station cost. Allowing this to be representative of farm conditions the man with an average herd is getting very little for his labor. He is living on the stored up fertility of his land.

This dairy industry began by each farmer keeping one or two cows to supply his own family. As villages grew and a demand

for dairy products was created the number of cows increased. Up to 1860 the industry was confined to the production of milk during the warmer months of the year, practically no winter milk being produced. The food for the animals was all grown on the farm and the butter and cheese manufactured there. Under this business system all cash received was net profit to the farmer. Since 1860 this has gradually changed, until in 1900, of the 135,000,000 pounds of cheese manufactured only about 2,000,000 pounds was made on the farms, the balance being manufactured in factories where the milk from a number of farms was combined. The labor required under the latter system is less, but this labor must be paid for by the farmer.

A similar change has been going on in connection with the making of butter, about two-thirds of which is now manufactured at central creameries.

A very noticeable change is in the sale of crude milk for use in the cities and villages, recent figures indicating that there is now more milk used for this purpose than is manufactured into butter and cheese. This trade demands as large a supply in winter as in summer and it is constantly demanding a better quality as regards both fat and sanitary conditions surrounding the production. To meet these demands requires increased expense.

The cost of labor is higher, which makes the coarse food and whatever else is produced on the farm cost more.

With these changed conditions and particularly the demand for winter milk it has been necessary to feed much more grain than formerly, and the item of purchased cattle food has reached such proportions as to require a vast outlay of money.

Purchased grain has increased 20 per ct. in the past five years so that, other things being equal, it cost the farmer considerable more to produce milk. On the other hand in the past four years the price paid the farmer for his dairy products has advanced about 18 per ct.

This has brought prices to a point where very much more advance will mean reduced consumption. It would certainly appear to be wise to avoid that contingency which would soon lead to a surplus and much lower prices.

From the above facts it is readily seen that the dairy business has become a much more complicated financial proposition than it was at its inception and that there is now much more opportunity for financial loss than when the labor of the farmer was the only item at stake. With conditions as they are, the individual producer can do little to increase the price obtained for his product and with the increasing price of labor cannot expect to reduce materially the cost of feeds. Practically the only opportunity for increasing his profits which is within his control is through increasing the productivity of the individual cow by keeping and breeding from his best and eliminating the ones that are not making a suitable return for the food consumed.

REPORT

OF THE

Department of Bacteriology.

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REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

THE CONSTANCY OF CERTAIN PHYSIOLOGICAL CHARACTERS IN THE CLASSIFICATION OF BACTERIA.*†

H. A. HARDING.

SUMMARY.

1. During the past fifteen years constant effort has been made to find a workable system of classifying bacteria. The Classification Card of the Society of American Bacteriologists is the direct result of this effort.

2. The group number on this card is a numerical expression for the result of ten physiological reactions. Its value as a basis for classification depends upon the constancy with which the same numerical result is obtained from tests of various strains of a single species. When tested upon forty-four strains of Pseudomonas campestris (Pam.) Smith, the same group number, 211.3332513, was obtained for each strain.

3. The limitation of the group number system of classification lies in the fact that, as constituted at present, it probably does not carry the separation to a group synonymous with the ordinary conception of species. These results indicate that further assistance in classification may be expected from pathogenicity toward plants, indol formation, casein digestion, growth in Uschinsky's and Cohn's solutions and turbidity in broth. The technique of these determinations must be given further study before these reactions will be serviceable.

*Also presented at as a thesis before the Faculty of Cornell University for the degree of Doctor of Philosophy.

†A reprint of Technical Bulletin No. 13.

INTRODUCTION.

Science is commonly defined as an orderly arrangement of facts, and in practically all branches of biology a classification of species is the basis on which the facts are arranged. Bacteriology, if it can be said to have attained the dignity of a science, has thus far developed so primitive a plan of classification that the observed facts are in many cases in a condition little short of chaos.

The idea of species was originally based on morphological similarity combined with ability to produce fertile offspring by sexual reproduction. With bacteria sexual reproduction is unknown and morphology is so simple that it has barely sufficed to differentiate the genera. The early work with bacteria was largely confined to pathogenic organisms and pathogenicity was relied upon to define the limits of the species. As the study extended to non-pathogenic forms reliance was placed on various other physiological reactions, singly or in combination, but there has been little agreement among workers as to the relative value of the various reactions which were commonly recorded.

The difficulty of arriving at a conception of bacterial species, sufficiently clear-cut to be useful in classification, led to the recognition of groups of related species, of which the colon group was perhaps the earliest generally accepted example. These groups were to be treated as units until such time as the progress of knowledge would allow them to be broken up into their component species. This tendency to recognize groups rather than species was largely followed by Kruse[1] in the third edition of "Die Mikroorganismen," by Conn[2] in his "Classification of Dairy Bacteria," and by Chester[3] in his "Determinative Bacteriology."

As has been suggested, there is a lack of agreement among

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1 Kruse, W. Einleitende Bemerkungen zur Klassifikation. Die Mikroorganismen. Flügge. 3d edition. Vol. II, pp. 67–96. 1896.

2 Conn. H. W. Classification of dairy bacteria. Storrs Agr. Exp. Sta., An. Rep. **12** (1899): 13–68. 1900.

3 Chester, F. D. A manual of determinative bacteriology. 1901.

workers both as to the reactions which should be used in separating species and as to the relative importance of these reactions. Recognizing the importance of a uniform and concise method of recording such reactions and desiring to designate the more important among them, the Society of American Bacteriologists adopted an official classification card for this purpose. An important part of this card was the "group number," in which the results of ten different reactions were expressed numerically. This number was so designated since at first it was short and was intended to characterize a group of species. It has now been extended much beyond its original length.

Since a collection of classification cards is ordinarily arranged on the basis of the group number it is important to consider how far this group number can be used for this purpose without separating two strains of the same species. The constancy of the reactions which govern the group number is the vital point upon which the Society card must be judged as a standard for classification.

Until the first report to the American Public Health Association of its committee on media there was no satisfactory basis for computing the constancy of characteristics since it was not clear whether the variations which were observed were due to variations in the germs themselves or in the conditions under which the tests were made. The original selection of the group numbers was made on the basis of general impressions among bacteriologists aided by the work of Fuller and Johnson[4] and that of Gage.[5]

With the recognition of the usefulness of the group number there is a growing desire to extend the range of the number until it shall classify cultures as closely in accord with the idea of species as possible. Accordingly it is imperatively necessary to know both the constancy of these reactions and the extent to which the group number can be followed in classification without separating various strains of the same species.

[4] Fuller, Geo. W. and Johnson, Geo. A. On the differentiation and classification of water bacteria. *Jour. of Exp. Med.* 4: 609–626. 1899. Also in Amer. Pub. Health Asso. Proc. 25: 580–586. 1899.

[5] Gage, S. DeM. Mass. Bd. of Health, An. Rep. 33 and following.

For this study it seemed desirable to select an organism in which the limits of what we commonly regard as a species are clearly defined and to study a large number of strains under as wide a variation in conditions as could be reasonably expected to occur in ordinary laboratory work. In doing this it was clearly recognized that the results which might be obtained with one species would not necessarily hold for all, but in view of the importance of this inquiry there seemed no better way than to make a beginning hoping that the example might stimulate others to extend the study.

The present study has been limited to various strains of one of the type species given on the society card, *Pseudomonas campestris* (Pam.) Smith, a form pathogenic to practically all of the cultivated *Cruciferæ,* and one in which the culture characteristics are well known. Cultures were isolated directly from diseased plants as well as obtained through the courtesy of colleagues in different parts of the country. Thus the study included cultures which were so fresh as to have experienced the minimum effect of artificial cultivation in the laboratory as well as those which had been exposed to the vicissitudes of artificial media in different laboratories for many months. Most of these latter cultures passed through the prescribed course of revivification before being studied but in a number of cases this revivification was intentionally omitted. The study extended over a year and a half, using media prepared by different workers and in some cases the observations were made by three workers separately. In short, the effort was made to find the maximum variation which could be expected where observations were made in accordance with the official directions or with the deviation therefrom which could be reasonably expected in practice.

ACKNOWLEDGEMENTS.

This study has been conducted under the immediate direction of Prof. B. M. Duggar, and it is a pleasure to record the value of the suggestions received both from him and from Dean V. A.

Moore. Cultures were kindly furnished by colleagues in various laboratories as noted in the body of the report and much assistance was rendered by Messrs. M. J. Prucha and J. K. Wilson. In all cases where there seemed room for a difference of opinion as to the manner of recording the reaction of a culture they kindly rendered independent judgments on the point in question and in so doing added much to the value of the results here presented.

The quickness with which the details of even important events are lost is shown by the difficulty in assembling the facts regarding the origin of the classification card. The information on this point was largely furnished by Messrs. S. DeM. Gage, Erwin F. Smith, F. P. Gorham and C. E. Marshall.

To the friends who are here mentioned and to the larger additional number who have contributed in various ways to the success of this work sincere thanks are respectfully rendered.

SEPARATION OF BACTERIA INTO GENERA BASED ON MORPHOLOGY.

Many classifications of bacteria have been proposed by different authors. In the decade preceding 1900 it was customary to recognize three bacterial genera — Coccus, Bacillus and Spirillum — based on a morphological resemblance to the sphere, the rod and the spiral.

The described forms having become too numerous to be conveniently grouped under three genera, Migula,[6] in 1894, proposed using the arrangement of the flagella as a basis for increasing the genera. Since the appearance of the second volume of his "System der Bakterien"[7] in 1900, his classification has been generally adopted. While there has never been complete agreement on the question of the basis for erecting genera the dissenting workers have quite uniformly based their genera on morphology, so that in the past morphology has generally furnished the basis for the separation of bacterial genera.

[6] Migula, W. Ueber ein neues System der Bakterien. Arbeiten aus dem bakt. Institut der Technischen Hochschule zu Karlsruhe. Bd. I. Heft I. 1894. Quoted from Migula. System der Bakterien. Bd. I, p. 46.

[7] Migula, W. System der Bakterien. Bd. II. 1900.

SEPARATION OF SPECIES ON A PHYSIOLOGICAL BASIS.

With the exception of spore formation, the morphological characters which are sufficiently definite to be useful in classification have been utilized by Migula in defining the genera so that the separation of species is necessarily on the basis of physiological reactions.

In his "System der Bakterien" Migula used as his main basis for separating the groups of species the chromogenesis, liquefaction, relation to air and form of colony growth in gelatin; the formation of spores and the manner of their germination; and in some cases the production of phosphorescence. With these reactions he divided the genera into groups and the species in each group were separated on whatever basis seemed most serviceable.

Chester[8] also followed the same general plan of dividing the genera into groups but he somewhat changed the basis on which these groups were formed. He retained the formation of spores as diagnostic but did not make use of the manner of their germination as Migula had done. He retained the chromogenesis, liquefaction and form of colony in gelatin, but used the terms aerobe and anaerobe instead of basing the division on the growth in gelatin stab.

To the reactions used by Migula for separating groups, Chester added Gram's stain, coagulation of milk, gas formation from dextrose and lactose and the nitro-indol reaction as well as the swelling of the rod in spore formation.

The classification of dairy bacteria by Conn[9] proceeded along the same general line, the aim being to reduce the flora of milk and its products to small groups which in many cases coincided with the common conception of species. He differed from Chester in not considering Gram's stain of sufficient diagnostic value to be used in this connection. He also made but slight use of the

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[8] See footnote 3.

[9] Conn, H. W., Esten, W. M. and Stocking, W. A. A classification of dairy bacteria. Storrs Agr. Exp. Sta. An. Rep. 18 (1906): 91–203. 1907.

different relations of bacteria to oxygen although this had been emphasized by both Migula and Chester. On the other hand he considered the formation of acid from dextrose as of great importance, placing it second to that of liquefaction of gelatin, although neither Migula nor Chester had made any particular use of this reaction.

A critical inspection of the work of each of these authors brings out the fact that they have formulated a classification which concerned itself with the forms which had already been described and which made no particular provision for any forms which might be found at a later date. This is shown by the fact that in the classification within the various genera, even where the same reactions were used to separate the various groups, these reactions were not placed in the same sequence. The reason for this lack of uniformity was the desire of the authors to keep the final groups so arranged that those which were arbitrarily considered to be closely related should not be widely separated by the plan of classification. In other words, the authors had more faith in their general sense of relationship than in their ability to arrange the diagnostic reactions which they had selected in a logical manner. It is evident that any such makeshift could be of only temporary utility, since the rapidly increasing volume of new species would soon call for a rearrangement.

As has been indicated, each of these classifications was the result of a study of a large number of described forms, but each lacked an adequate provision for the placing of any new form which might be later encountered.

NEED OF A CONSTRUCTIVE CLASSIFICATION.

The fact is gradually coming to be recognized that if bacteriology is to take its place as a modern science the first requisite is a knowledge of the normal flora, including a knowledge of the effects upon that flora of the ordinary changes in its environment. Such a knowledge is fundamental to a proper understanding of diseases and fermentations and must be obtained before we can expect to control successfully the action of micro-organisms.

The obstacle which has thus far prevented any marked progress in this direction is the crudeness of our system of classification. The process of comparing an unknown form with the descriptions of previously studied organisms is extremely laborious, because practically every organism has been described on special media and under special conditions which must be duplicated before a satisfactory comparison can be made. Too often the conditions under which the earlier form was studied are unknown and an exact comparison is accordingly impossible.

This inability to use the results of previous workers has compelled each student to begin with the fundamentals of his problem, and the total progress in any line was practically limited to the product of a single individual since the laboriously acquired facts applied only to the circumstances under which they were observed. The absence of a common basis for comparing these isolated facts has prevented their orderly arrangement and has made accurate generalizations impossible.

The prime requisite for acquiring a knowledge of the bacterial flora is a classification which shall be so concise as to permit of fairly rapid progress in actual classification and yet so exact as to furnish a firm foundation upon which later workers can build. The aim of the first student of any field should be to reduce the flora to its main subdivisions, after which these subdivisions can be subjected to detailed study. Our knowledge of the action of bacterial protoplasm is yet so limited that no one can predict all of the reactions which will be ultimately used in classifying bacteria, but a considerable number are now known which will undoubtedly be useful in this connection.

One of the stumbling blocks in the past has been the attempt to produce a so-called natural classification,[10] that is, one which should record the steps by which the originally simple forms gradually evolved into those which were more complex. In bacteria we have the simplest form of life in which the protoplasm is

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[10] A recent example is the system of O. Jensen. Die Hauptlinien des natürlichen Bakterien-systems. *Cent. f. Bakt.* II, 22: 305–346. 1909.

constantly responding to the stimuli of its environment and becoming modified in new ways. Considered chronologically, the differentiations of spore formation, enzym production and ability to live without a supply of free oxygen undoubtedly occurred in some definite order. Whatever this order may have been, the original forms have long since disappeared and their descendants have continued to differentiate until the forms which are now encountered present a bewildering complex of modifications.

After some workable basis of observation has been established and a large number of reliable and comparable observations are made available it may be possible to trace in part the order of original development. Until such data are available attempts at formulating such a natural classification are guesswork and are not worthy of serious scientific consideration. In the present state of knowledge it makes little difference what are taken as primary and as secondary lines of demarcation in any classification so long as the selected reactions really separate forms, are readily determinable and give constant and clear-cut results. On the other hand the applicability of a system of classification is increased by using only a limited number of differentiating reactions and using them constantly in the same sequence.

Two points in this connection stand out quite clearly. First, there is a growing tendency to use items which have the sharpness of chemical reactions, such as the production of gas and acid from sugar, instead of items which must be measured by general sense impressions, such as the form of colonies. Second, that in matters of classification the qualitative rather than the quantitative action is to be considered. The time will come, when the first general arrangement of the flora is completed and the task of working up the groups in detail is begun, when the influence of environment will be brought into strong relief by a study of the quantitative reactions. The main reason for not undertaking this study at the present time is the fact that the increase in routine which it entails would practically block progress.

ORIGIN OF THE SOCIETY CLASSIFICATION CARD.

The two features which most strongly commend the classification card are that it is in the form of a card and that the principal results are expressed numerically. The utility of cards for recording information in a readily accessible form was undoubtedly first brought prominently to the attention of scientists through the card catalogues at libraries.

The original suggestion of the use of numbers in connection with bacterial classification seems to have been in 1895 by Wyatt Johnson,[11] who said: "It has occurred to me that all of the important characteristics of a given species might be recorded more compactly than at present if a system were adopted by which the information furnished by the various tests could be represented by means of numbers, each stated in a definite order so as to form a code." The present application of these ideas has come in successive steps, each preparing the way for the succeeding one, and each logically following from what had preceded.

On the initiative of Dr. Wyatt Johnson of Montreal a convention of American bacteriologists was called by a committee of the American Public Health Association. This convention assembled in New York in June, 1895, discussed the situation carefully, and appointed a committee to draw up procedures for the study of bacteria in a uniform manner and with special reference to the differentiation of species. A statement in the report of this committee[12] to the American Public Health Association in 1897 well summarizes the situation. "The committee recognizes fully that these recommendations must of necessity be provisional. It publishes them in the hope that by this act it will direct attention to the urgent need now existing for a full and accurate

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11 Johnson, Wyatt. On grouping water bacteria. Amer. Pub. Health Asso. Proc. **20**: 445–449. 1895.

12 Proceedures recommended for the study of bacteria with especial reference to greater uniformity in the description and differentiation of species. Being the report of a committee of bacteriologists to the Committee on the Pollution of Water Supplies of the Amer. Pub. Health Association. Amer. Pub. Health. Asso. Proc. **23**: 60–100. 1898.

description of species of bacteria in which the items have been determined by methods common to the main body of workers, and as a consequence are capable of verification and control." The activities of this committee, which rendered a final report in 1904,[13] by unifying methods of making media and observing cultures, furnished an indispensable foundation for the accumulation of a mass of comparable facts regarding the characteristics of bacteria.

Given this constantly accumulating mass of somewhat comparable observations, the next question was the selection of those reactions which were sufficiently constant with any given species to warrant their being used to characterize the species. While this question is yet far from being settled in its entirely, a good beginning was made by Fuller and Johnson[14] in 1899. With seven different species which had been long cultivated in the laboratory they obtained diametrically opposed results when tested before and after a preliminary cultivation to return them to a vigorous condition. After such preliminary cultivation, eleven species from water gave 100 per ct. of constancy with each of fourteen selected reactions. These authors divided the water bacteria which they had studied into thirteen groups on the basis of fluorescence, chromogenesis, liquefaction, form of colony and fermentation of carbohydrates. They separated the members of each group on the basis of twenty-six reactions, the behavior of each culture being expressed by + or —. Using this manner of recording their observations they presented the classification and culture reactions of forty-two species on a single chart, a striking illustration of clearness and conciseness.

This manner of presenting results was at once taken advantage of by Conn.[15] As his adaptation was made shortly before the publication of the results from a long study of dairy bacteria,

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[13] Report of Committee on Standard Methods of Water Analysis to the Laboratory Section of the Am. Pub. Health Asso. *Jour. of Inf. Dis.* Sup. No. I, May, 1905.

[14] See footnote 4.

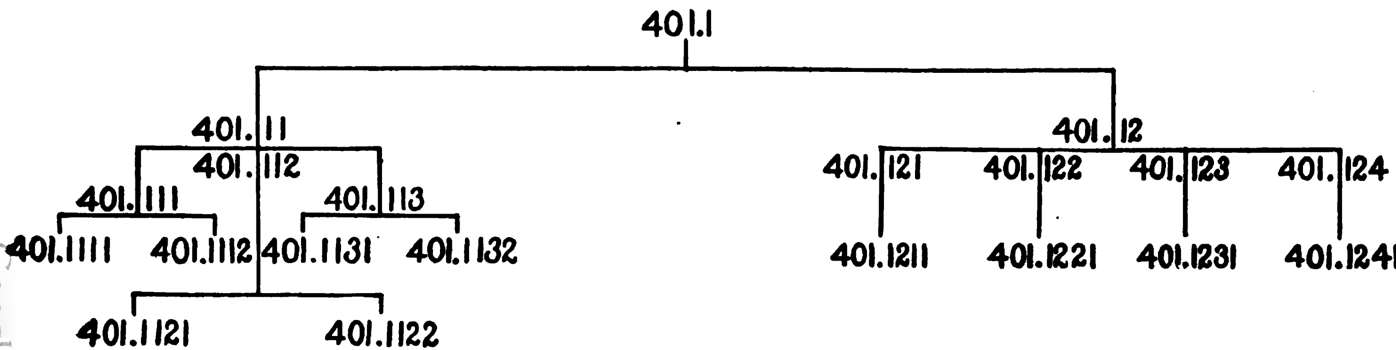
[15] See footnote 2.

some modifications of the form were necessary. He says: "For these reasons the tables which I have been obliged to make out and to use differ in some details from those of Fuller and Johnson. I have, however, followed them as closely as possible." The dairy flora was divided into ten groups instead of thirteen, the first four being identical with the fluorescent and chromogenic groups of Fuller and Johnson, the remainder being formed on the basis of rod or coccus form, liquefaction and spore formation. These groups were subdivided on the basis of thirty-three headings which differed but slightly from those used by Fuller and Johnson. In addition to this table, Conn gave a written description of each species which extended and explained the tabular results. The arrangement of the headings employed by Conn will be better understood by referring to the accompanying reproduction of Conn's card. Fig. 1. This list omits liquefaction of blood serum, nitrate and indol production and pathogenicity toward mice as used by Fuller and Johnson and adds the columns headed coccus, uniting in chains, sediment, proteus-like, moss-like, deep-funnel, needle growth, surface growth, gas produced, acid, alkaline and slimy.

FIG. 1.— CONN'S FIRST CARD.

Lab. No.	NAME.	MORPHOLOGY.						CULTURAL FEATURES.																BIOCHEMICAL FEATURES.										
								Nutrient broth tube.			Nutrient agar tube.		Gelatin plate.			Gelatin stab.					Potato tube.					Milk.								
		Bacillus.	Coccus.	Diam. greater than 1μ.	Motile.	Uniting in chains.	Spores.	Turbidity.	Scum.	Sediment.	Dull.	Wrinkled.	Characteristic.	Proteus-like.	Moss-like.	Liquefies.	Deep funnel.	Needle growth.	Surface g'wth.	Gas produced	Visible	Luxuriant.	Fermentation tube Growth in closed arms.	Grows at body temperature.	Facultative anaerobic.	Curdles.	Acid.	Alkaline.	Digests.	Slimy.	Strong odor.	Chromogenesis.	Fluoresence.	Gas production.

FIG. 2.— DIAGRAM ILLUSTRATING RICKARD'S SYSTEM.



An early attempt at using cards for recording general laboratory data, including a numerical system for designating the individual cultures from which the data were derived was made by Rickards,[16] who described it as follows:

"The writer's system is an adaptation of the Dewey Decimal System of Classification,* the method of use being such as is easily remembered.

"Every species of bacteria, upon becoming a member of the laboratory stock, is given a number in the hundreds. Thus:

B. coli communis	100	*B. mallei*	400
B. typhi abdominalis	200	*B. prodigiosus*	500
B. diphtheriae	300	*B. pestis bubonicae*	600

Individual specimens of any one species, coming from different sources, are numbered in the order of their isolation or reception with the units from 1–49. Thus:

B. mallei from one horse	401
" " " a second horse	402
" " " a different lesion in the second horse	403
" " " same lesion at a different time	404
" " " a third horse	405

"The first culture of *B. mallei* isolated would be 401.1.

"A sub- (or daughter) ** culture from this original culture would be 401.11.

"A sub- (or daughter) culture from this second culture would be 401.111, and so on — each *sub*-culture bearing the number of the mother culture from which it was taken, with one figure more placed one space more to the right of the decimal point. If but one sub-culture is made this added figure is always one. If more than one sub-culture is made the first of these sister cultures is designated as above (the number of the mother culture with one in the next right decimal place), the second by two in the same place of decimals, etc., 401.11, 401.12, 401.13, etc.

"This may be better illustrated by a graphical sketch [Fig. 2.]

(It will be seen from the above that a single daughter culture is always expressed by the number of the mother culture with the figure 1 placed in the next right place of decimals, and that further cultures made from the same given mother culture are expressed by increasing this last new figure in arithmetical order. This is the key to the system.)

"If at any time more than nine sister cultures are made from any one culture, the figures above nine are inclosed in brackets to avoid confusion, *e.g.*, 404.18, 404.19, 404.1(10), 404.1(11), etc.

"In cases where the numbers have become somewhat unwieldy, they may often be abbreviated by using exponents, *e. g.*, $401.1111121113 = 401.1^5 21^3 3$.

"When an *unidentified* organism is *isolated*, it is given the specific num-

* Dewey, M. Decimal classification and relativ index.

** "For the sake of convenience and clearness, the following terms have been adopted in this article:
Mother culture.— The culture from which another culture is inoculated.
Daughter culture.— The sub-culture from the mother culture.
Sister cultures.— Two or more cultures made from the same mother culture.
(Obviously the terms are relative. It is evident that any one culture may be a mother, a daughter, and a sister culture at the same time.)"

16 Rickards, B. R. A system of recording cultures of bacteria genealogically for laboratory purposes. Boston Health Dept. An. Rep. 30 (1901): 75–79. 1902.

ber in hundreds which designates the species which it most resembles, but with the tens and unit figures running above 50; thus, a glanders-like organism would be numbered 451, etc., pending its further examination. If found to be glanders it would be renumbered below 450, taking the number next above that of the glanders culture last isolated.

"*Unidentified* organisms having no striking resemblance to any species possessed by the laboratory are classed by themselves under one species number (*e. g.*, 10,000), until identified.

"A card system is used in connection with this system of numbering, offering a complete record."

The next marked advance in the matter of keeping records with a view to ease of comparison and classification of results was made at the Lawrence Experiment Station[17] in connection with the routine examination of water, principally for *B. coli.* This contribution was noteworthy because it introduced the numerical expression for the group (group number) and emphasized the card as the best form for keeping and comparing such records. It is further important because some of the suggestions in it might be applied with profit to our present official classification card.

It can be best described in the words of its authors:[18]

"The attempt at a numerical classification at the Experiment Station arose in an effort to classify existing bacterial literature under the decimal system in common use for library cataloging. The credit for the first practical suggestion along this line should be given to A. I. Kendall, at that time a member of the bacteriological force at the Experiment Station, from whose preliminary scheme the system in use at the present time has been the logical outgrowth. The system of numerical classification has already been described by one of the writers,* the extension of this system to the complete record, with the use of cards, is here described for the first time.

"In the system all of the characteristics of a species are described by number, this number being derived from the combination generally of two or more allied characteristics.

"The group number is represented by four figures, of which the first two digits signify the morphological genera, the form, method of division, motility, and arrangement of flagella, according to the accepted classification of Migula.

These are derived as follows:

1. *Coccaceae.*
    11. Streptococcus, division in one plane.
    12. Micrococcus, division on two planes.

* [See footnote (17).]

[17] Gage, S. DeM. Bacteriological studies at the Lawrence Experiment Station with special reference to the determination of *B. Coli*. Mass. Bd. of Health. An. Rep. **33** (1901): 397–420. 1902.

[18] Gage, S. DeM. and Phelps, E. B. On the classification and identification of bacteria with a description of the card system in use at the Lawrence Experiment Station for records of species. Amer. Pub. Health. Asso. Proc. **28** (1902): 494–505. 1903.

13. Sarcina, division in three planes.
14. Planococcus, motile coccus.
15. Planosarcina, motile sarcina.

2. *Bacteriaceae.*
 20.**Motile rods, flagella not determined.
 21. Bacterium, non-motile rods.
 22. Pseudomonas, *a*, motile rods, flagella monotrichic.
 23. Pseudomonas, *b*, motile rods, flagella lophotrichic.
 24. Bacillus, motile rods, flagella peritrichic.

3. *Spirillaceae.*
 31. Spirosoma, cells rigid, without flagella.
 32. Microspira, cells rigid, one (rarely 2–3) polar flagellum.
 33. Spirillum, cells rigid, polar flagella tufts.
 34. Spirochaeta, cells flexuous.

The morphological genera are sub-divided by the differences in certain well-recognized cultural and biochemical features.

This sub-division, forming part of the whole group number, consists of two digits, of which the third group figure indicates the biochemical features of the liquefaction of gelatin and the production of gas or acid in dextrose broth, as suggested by Groups IX to XIII of Fuller and Johnson. The derivation of the nine digits used in this place is as follows:

	Gelatin.	*Dextrose Broth.*
1.	Non-liquefied.	No gas or acid produced.
2.	Non-liquefied.	Acid produced, no gas.
3.	Non-liquefied.	Gas produced.
4.	Liquefied.	No gas or acid produced
5.	Liquefied.	Acid produced, no gas.
6.	Liquefied.	Gas produced.
7.	†Doubtful.	No gas or acid produced.
8.	†Doubtful.	Acid produced, no gas.
9.	†Doubtful.	Gas produced.

"The digit in the fourth place shows the fluorescence and chromogenesis on agar, the grouping being similar to that in Groups I to VIII of Fuller and Johnson.

"These are distinguished as follows:
1. All fluorescent species, irrespective of their chromogenesis.
2. All red chromogenic species.
3. All orange chromogenic species.
4. All yellow chromogenic species.
5. All blue and violet chromogenic species.
6. All green chromogenic species.
7. All brown chromogenic species.
8.
9. All others not included in the above.

"By the use of such a system as the above, the arrangement of bacteria into groups becomes at once a simple and exact matter. We no longer have the old, rather indefinite question, does our species belong to the colon

** 20 is provisional group, and should disappear, its members falling into groups 22, 23 or 24.

† In groups 7, 8 and 9, would be included the so-called thermophylic species which do not grow at the temperature at which gelatin is solid.

group, or to the hog cholera group, or to some other equally indefinite group? We simply drop our colon bacillus into slot No. 2439, or our sewage streptococcus into No. 1129, and they immediately find themselves in congenial company.

"The system of recording reactions by means of plus or minus signs, used by Fuller and Johnson in their compilation of the bacterial flora of the Ohio river, was a distinct advance over the verbose written descriptions of earlier investigators.

"To reduce the size of the tables and render comparisons more easy we may either reduce the number of tests tabulated or we may combine these tests in some manner so that two or more tests may be recorded in the space at present occupied by one.

"The reduction of the number of tests is not feasible if we would wish to have anything like complete data. As a means for combining the data without curtailing either its volume or its usefulness, the numerical system here described has proved quite successful.

"As a basis for the system we start with the assumption that all of the tests usually applied in species differentiation may be logically divided into groups of three, any one, two or three of which may be positive. Arranging these three tests, A, B, C, in the order of negatives we derive eight numbers, each one representing some combination of the positive and negative values of the three tests, as follows:

	A	B	C	
1	0	0	0	All negative.
2	0	0	+	Two negative, one positive.
3	0	+	0	
4	+	0	0	
5	0	+	+	One negative, two positive.
6	+	0	+	
7	+	+	0	
8	+	+	+	All positive.

"A glance at any one of the tabular descriptions of species of the present day will show that there are usually three characteristics recorded on each medium, and an arrangement by media is at once suggested. There are some tests, however, which at first appear to introduce complications. For example, in the arrangement of tests further on, under milk, we have coagulation, acid reaction, and alkaline reaction as values for A, B, C in the table of numbers. It is manifestly impossible for a reaction to be at the same time acid and alkaline.

"This, however, does not vitiate the values for the other numbers, the digits 5 and 8 simply becoming non-existent. Under aerobiosis we have a more extreme case, only one of the three values used being possible at one time. In this case all of the digits except 2, 3 and 4 become silent, but as we are concerned only with the live numbers, this tends to simplify, rather than to complicate matters. In the case of pathogenesis and the indol

FIG. 3.— TABLE SHOWING GROUPS OF TESTS UNDER NUMERICAL SYSTEM.

Column	GROUP.	A.	B.	C.	Digits.
1	Morphology	Spores	Capsules	Gram stain	1 to 8 inclusive.
2	Liquefaction	Gelatin	Casein	Serum	1 to 8 inclusive.
3	Dextrose broth	Gas	Acid	Growth in closed arm	1 to 8 inclusive.
4	Lactose broth	Gas	Acid	Growth in closed arm	1 to 8 inclusive.
5	Saccharose broth	Gas	Acid	Growth in closed arm	1 to 8 inclusive.
6	Milk	Coagulated	Acid	Alkaline	1, 2, 3, 4, 6, 7 only.
7	Nitrate reduced	Nitrites	Ammonia	Nitrogen	1 to 8 inclusive.
8	Indol produced	....	....	....	1 and 8 only.
9	Nutrient broth	Turbid	Pellicle	Sediment	1 to 8 inclusive.
10	Gelatin stab	Craterform	Infundibuliform *	Stratiform	1, 2, 3, 4 only.
11	Agar streak	Luxurient	Dull or winkled	Viscous	1 to 8 inclusive.
12	Potato	Visible	Luxuriant	Discolored	1, 2, 4, 6, 7, 8 only.
13	Temperature	Grows better at 20° C.	Grows equally well at 20° or 38°	Grows better at 38° C	1, 2, 3, 4 only.
14	Aerobiosis	Obligate aerobe	Facultative	Obligate anaerobe	2, 3, 4 only.
15	Pathogenesis	....	....	....	1 and 8 only.

* Including napiform and saccate.

reaction, where we have the positive and negative values for only one function, we should use only the digits 1 and 8 as representing the extreme negative and positive limits.

"Of course it would be possible to have a separate arrangement for such cases as these, or we might combine two or more of them, but this would tend rather to confusion than to simplicity. Throughout the system as arranged, only similar tests have been combined, the application of a number of other combinations having been shown by a trial to lead to confusion.

"In the application of the system to various tests, only such tests have been retained as have given constant results, and which can be duplicated at any time with media of a constant composition and with cultures in the proper condition for study, *i. e.*, after efficient preliminary cultivation. The order of the tests is based on their probable value in species differentiation. This order, with the division of the tests into groups, and the various figures representing the various combinations which would appear in a tabulation of species by this method, is shown in the preceding table. (Fig. 3.)

"The writers have devised a form for use at the Experiment Station, which proves to be so convenient, that it is here described for the benefit of others who wish to break away from the inconveniences of the older methods of keeping species records. The form shown is self-explanatory. Records are made in the columns on the right by plus and minus signs and a few well-known symbols. There is sufficient room in the body of the blank for notes and for such descriptive matter as is not recorded in the columns, while additional notes and drawings may be made at the bottom and on the back of the card.

"The entries in the spaces across the top are made by the numerical system heretofore described. The form is printed on a good grade of card stock, this being easier to handle and more durable than paper. The size of the card, eight by ten and one-half inches, is the same as the regular letter sheet, and cards may be filed in any of the numerous vertical cabinets which are on the market. The cards are filed in numerical order by the system already described. By this method, similar species come on adjacent cards and it is a simple matter to weed out identical cultures. Comparisons of descriptions are made by laying the cards down so that only the marginal columns are visible, the comparison being either the plus and minus signs or the numerical nomenclature, the numerical grouping rendering the comparison of only a few cards necessary at any one time. We have found it to be very convenient to enter descriptions of other writers on this form, filing these cards with our own descriptions, thus eliminating reading back and forth from one system to another. The reduction of other descriptions to this form is not as laborious as would at first appear, the ruling of the form being so spaced that the copying may be readily done on the typewriter.

"The ruled form follows: [Fig. 4.]

[FIG. 4.—] FORM USED FOR BACTERIAL DESCRIPTIONS AT THE LAWRENCE EXPERIMENT STATION.
(Reduced.)

Group.	Morph.	Liq.	Dex.	Lact.	Sac.	Milk	KNO_3.	Indol.	Broth.	Gel.	Agar.	Potato.	Temp.	Aerobe.	Path.		Culture.
NAME.						INVESTIGATOR.					SOURCE.				ISOLATED.		

	Morphology.	Spores	Length	Diameter	Form
		Capsules	Gram's	Flagella	Motile
	Gelatin Stab.			Form	Liq.
	Gelatin Plate.			Form	Liq.
Dextrose.	Fermentation Tube.		C. A.	Acid	Gas
Lactose.			C. A.	Acid	Gas
Saccharose.			C. A.	Acid	Gas
	Agar Streak.	Lux.	Viscous	Wrinkled	Dull
				Chrom.	Fluor.
	Agar Plate.				
	Broth.		Sediment	Pellicle	Turbid
	Milk.		Reaction	Pept.	Coag.
	Nitrates.		N.	NH_3	HNO_2
	Indol.				
	Potato.		Discolor	Lux.	Visible
	Serum.				Liq.
	Pathogenesis.				
	Litmus Lactose Agar.			T. B.	Red
	Temperature.			38°C.	20°C.
	Odor.				

This work by Gage and his associates was in many ways the most important contribution which has been made to this plan of classification, since it introduced not only the use of the card and the group number but also many other details which have been or will be used in this connection.

At the same meeting of the American Public Health Association, Kendall,[20] who had assisted in the development of the Lawrence card while an assistant to Gage, presented a similar card with the additional feature that the details of the culture growths were expressed by numbers. When the time comes for the study of the effect of changes in environment upon the finer details of culture characteristics the plan of Kendall or something similar will be found useful. At the present stage of the science his system is entirely too cumbersome.

Conn now prepared a new card which was a copy of that of Gage with some extensions, particularly in the matter of milk. This was natural, as Conn was principally interested in the milk flora. A copy of this card is given in Fig. 5.

During his extended study of bacteriological literature Chester[21] had been impressed with the futility of the current methods of describing species and was looking for an improved method. The paper by Gage and Phelps before the American Public Health Association impressed him so strongly that in August, 1903, he applied to Gage[22] and obtained a supply of the Lawrence cards for use in his own laboratory.

The failure of the American Public Health Association committee to proceed after its report on standard media created a general feeling that the Society of American Bacteriologists should take up the problem of classification. Chester presented the matter so forcibly at the Philadelphia meeting in December, 1903, that a Committee on Identification of Bacterial Species was

[20] Kendall, A. I. A proposed classification and method of graphical tabulation of the characters of bacteria. Amer. Pub. Health Asso. Proc. 28 (1902): 481–493. 1903.

[21] See footnote 3.

[22] Letter to S. DeM. Gage, dated Aug. 20, 1903.

appointed consisting of Messrs. F. D. Chester, F. P. Gorham and Erwin F. Smith.

At the Philadelphia meeting in December, 1904, Chester presented a paper[23] in which he introduced and explained the group number as given on page 77. This paper was virtually a preliminary report of his committee, presented for suggestions and criticism. In the autumn of 1905, the first society card, reproduced in Figs. 6 and 7, and a separate explanatory folder, given below, were distributed to members of the society. This first card was 5 x 8 inches, printed on both sides.

THE SOCIETY OF AMERICAN BACTERIOLOGISTS.

Preliminary Report of the Committee on Methods for the Identification of Bacterial Species.

The study of bacteria for purposes of grouping calls for a recognition of two classes of characters, (1) salient features, which have primary value taxonomically and (2) detailed features, which serve to distinguish strains, races and varieties.

The division of the Schizomycetes into genera is that proposed by Migula and is based upon morphology. The division of the genera into groups is as yet a provisional, or a purely artificial one. It serves however to identify organisms, and is useful at least to that extent.

The salient features of an organism belonging to any one genus can be conveniently expressed by a series of digits, representing a whole number and a decimal. This system readily enables organisms having similar characters to be brought together and grouped about some central organism or type. The system is shown in Table I.

An attempt has been made to arrange the characters in the order of their importance. It will be observed that chromogenesis has been placed last. This is contrary to prior notions. Chromogenesis is a variable character dependent upon environment. Organisms frequently show constancy in all the characters which precede but may show altered or negative chromogenesis. Many forms are identical in all the preceding characters and differ among themselves only in the presence or absence of pigment. To separate them widely would do violence to a rational system of grouping.

The past literature of bacteriology abounds in such imperfect descriptions of organisms as to make their grouping, according to any system, impossible. This fact calls for the adoption of some scheme to which all descriptions shall conform, in order that no essential character shall be overlooked.

The accompanying card is proposed for the recording of the characters

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23 Chester, F. D. Principles of classification of bacteria. Report of Phila. Meeting of Dec. 27–8, 1904. In *Science* N. S. **21**: 485–486. 1905; and *Cent. f. Bak.* **II, 15**: 240–241. 1905.

FIG. 6.— FRO

SALIENT FEATURE:

Genus	Group No. or Character Complex[1]	Morph.			CULTURAL FEAT											
					Broth			Agar		Gel. Plate					C	
Name		Diam. over 1 micron.	Chains	Spores	Turbidity	Scum	Sediment	Dull	Wrinkled	Round, Compact	Proteus-like	Rhizoid	Filamentous	Curled	F...	
Source																
Cult. No.																

DETAII

I. MORPHOLOGY.

1. Vegetative Cells.

Form, *round, short rods, long rods, filaments, commas, short spirals, long spirals, clostridium, cuneate, clavate.*

Limits of Size.[3]

Ends, *rounded, truncate, concave.*

Agar Block [2]: Orientation (grouping). Chains (No. of elements),[4] .... *short chains, long chains.* Orientation of Chains, *parallel, irregular.*

2. Sporangia.

Form, *elliptical, short rods, spindled, clavate.*

Limits of Size.

Agar Block: Orientation (grouping). Chains (No. of elements). Orientation of Chains.

Location of Spores.

3. Spores.

Form, *round, elliptical,* (2× diam.) *elongated.*

Limits of Size.

Wall.

Naked.

Sporangium wall adherent.[5]

Germination, *e*
by stretching.

4. Flagella No..
Arrangement.

5. Capsules, pre

6. Staining Rea
1:10 watery fu
Special Stains.
Fat..........
Neisser.......
Glycogen.....

II. CULTURAL FE

1. Agar Stroke.
Form of grov
spreading, pl
Elevation of gr
Lustre, *glisteni*
Topography, *s*
Optical Charac
Chromogenesis
Consistency, *s*
nous, coriace
Medium discol

FIG. 7.— BACK

6. Broth.

Surface growth, *ring, scum, floculent, membranous, none.*

Turbidity, *slight, moderate, strong, transient, persistent, none.*

7. Milk.

Coagulation.

Liquefaction ....10 d........4 w........

Reaction in 2 d[8]......4 d.........10 d.......

Consistency, *slimy, viscid, unchanged.*

Medium discolored.

Milk agar.

8. Gelatin Colonies.

Form, *punctiform, round, irregular, ameboid, mycelioid, filamentous, rhizoid.*

Elevation, *flat, effused, raised, convex, pulvinate, crateriform,* (*liquefying*).

Edge, *entire, undulate, lobate, erose, lacerate. fimbriate, cilliate, filamentous, flocose, curled.*

Internal structure, *amorphous, finely—coarsely-granular, grumose, filamentous, flocose, curled.*

9. Agar colonies.
Form (as befo
Elevation " "
Edge " "
Internal Structu

10. Relative grow

III. BIOCHEMICAL

1. Fermentation
Gas production.
H. CO_2 ratio.
Growth in close
Acidifying coeffi

2. Fermentation
Gas production.
H. CO_2 ratio.
Growth in close
Acidifying coeffi

3. Fermentation
Gas production.
H. CO_2 ratio.

S (Partly included in Group No.)

URES							BIOCHEMICAL FEATURES											ADDITIONAL SALIENT OR DIAGNOSTIC FEATURES
Gel. Stab			Potato				Liquefaction [7]			Milk								
F[unnel]	Surface Growth	Needle Growth	Starch destroyed	Abundant	Discolored	Grows at 37°C	Gelatin	Casein	Blood Serum	Curdled	Acid	Alkaline	Indol	H_2S	Ammonia	Nitrates reduced	Gram's stain	

ED FEATURES.

quatorial, oblique, polar, bipolar,

....

sent on..........

ctions.

chsin..........

....

...

....

ATURES. [6]

rth, filiform, echinulate, beaded,
umose, arborescent, rhizoid.
owth, flat, effused, raised, convex.
ng, dull, cretaceous.
nooth, contoured, rugose, verrucose.
ters, opaque, opalescent.

limy, butyrous, viscid, membra-
us, brittle.
ored.

2. Potato.
   Form of growth (as before).
   Elevation " "
   Lustre " "
   Chromogenesis.
   Consistency as before.
   Medium discolored.
3. Blood serum.
   Form of growth (as before).
   Elevation " "
   Lustre " "
   Topography " "
   Chromogenesis.
   Medium discolored.
   Liquefaction.......10d........ 4w........
4. Agar Stab.
   Line of puncture, filiform, beaded, papillate, villous, plumose, arborescent.
5. Gelatin Stab.[7]
   Line of puncture (as before).
   Form of liquefaction, crateriform, napiform, infundibuliform, saccate, stratiform.
   Surface growth.

NOTE—Underscore required terms. Observe accompanying notes and glossary of terms.

OF FIRST SOCIETY CARD.

ore)..........

....

....

ure (as before)........

th at 20° and 37°C.

FEATURES.

of dextrose.

d arm.
cient [9] 2 d....4 d....10 d.....

of lactose.

....

d arm.
cient 2 d....4 d.....10 d.....

of saccharose.

Growth in closed arm.
Acidifying coefficient 2 d....4 d.....10 d.....

4. Fermentation of............

5. Ammonia production,[10] feeble, moderate, strong.

6. Reduction of nitrates in nitrate broth.[11]
   Presence of nitrites............
   " " ammonia..........
   " " nitrates............
   " " free nitrogen.......

7. Indol.

8. H_2S.

9. Starch Jelly.

IV. PATHOGENESIS.

V. ADDITIONAL DATA.

of an organism. The salient features at the top of the card are expressed by the group number and by + or — signs.

The detailed features are expressed by means of an appropriate terminology.

The cards can be filed like catalogue cards, and arranged in accordance with the group number, thus bringing similar organisms together and rendering comparison easy. The reference numbers scattered through the text of the card refer to the appended notes. There is also attached a glossary of terms.

TABLE I.

A Numerical System of Recording the Salient Characters of an Organism.

100.	Endospores produced
200.	Endospores not produced
10.	Aerobic (Strict)
20.	Facultative anaerobic
30.	Anaerobic (Strict)
1.	Gelatin liquefied
2.	Gelatin not liquefied
0.1	Acid and gas from dextrose
0.2	Acid without gas from dextrose
0.3	No acid from dextrose
.01	Acid and gas from lactose
.02	Acid without gas from lactose
.03	No acid from lactose
.001	Acid and gas from saccharose
.002	Acid without gas from saccharose
.003	No acid from saccharose
.0001	Nitrates reduced
.0002	Nitrates not reduced
.00001	Fluorescent
.00002	Violet chromogens
.00003	Blue chromogens
.00004	Green chromogens
.00005	Yellow chromogens
.00006	Orange chromogens
.00007	Red chromogens
.00008	Brown chromogens
.00009	chromogens
.00000	Non-chromogenic

The genus according to the system of Migula is given its proper symbol which precedes the number thus:

BACILLUS COLI (Escherich) Migula becomes	B.	212.11110
BACILLUS ALCALIGENES Petruschky becomes	B.	212.33310
PSEUDOMONAS CAMPESTRIS (Pammel) Smith	Ps.	211.33315
BACTERIUM SUICIDA Migula (Pammel) Smith	Bact.	212.2320

NOTES.

(1) For decimal system of group numbers see Table I.

(2) Hill: "Hanging-block" Preparations for the Microscopic Observation of Developing Bacteria: Jour. Med. Research, 1902, I, No. 2. Chester: A Review of the Bacillus Subtilis Group of Bacteria, Centralblatt f. Bakteriol, 2 te Abt. 1904, XIII, 739.

(3) Chester: l. c. p. 738.

(4) Chester: l. c. p. 741.

(5) Chester: l. c. p. 742.

(6) The composition, method of preparation, and reaction of all media should be given in connection with the description of cultural features (See revised methods of Laboratory Section of Am. Pub. Health Assoc., 1905).

(7) Gelatin stab cultures should be held for 4 weeks to determine liquefaction.

(8) Remove an oese of the culture, deposit same on strip of Squibb's neutral litmus paper, by the side of which is placed a similar quantity of the blank, or titrate 5 c. c. with $\frac{N}{20}$ NaOH.

(9) Titrate with $\frac{N}{20}$ NaOH using phenolphthalein as an indicator: make titrations at same times from blank. Acidifying coefficient equals titre of culture divided by titre of blank.

The titration should be done after boiling to drive off any CO_2 present in the culture.

(10) Place 1 c. c. of culture in one 50 c. c. Nessler jar and 1 c. c. of blank in another; fill to 50 c. c. mark with ammonia-free water; add 2 c. c. of Nessler reagent to each tube and compare tints; compare tints before precipitation occurs.

(11) Nitrates may be reduced to ammonia and free nitrogen and no nitrates may be present: this, however, is equivalent to a reduction. Test for nitrites by the starch, iodide of potassium, sulphuric acid test. Determine nitrates in culture and blank by the phenol-sulphonic acid method, using 1 c. c. of each.

Also compare ammonia, by method in note 10, in nitrate and plain broth cultures of same age and also in uninoculated nitrate broth of same batch.

GENERAL NOTE — Observations on morphology of vegetative rods to be made on 18 to 24 hour agar stroke cultures grown under optimum conditions. Observations of cultural features to cover a period of at least 10 days. Determination of acid production to be made on second, fourth and tenth days of growth. Ammonia, indol and nitrite tests to be made at end of tenth day. Observations on liquefaction to be extended four weeks.

GLOSSARY OF TERMS.

ARBORESCENT, a branched, tree-like growth.

AMEBOID, assuming various shapes like an amœba.

BEADED, in agar strokes, disjointed or confluent colonies; in agar stab disjointed or confluent colonies along the line of inoculation.

BRITTLE, growth dry, friable under the platinum needle.

BULLATE, growth rising in convex prominences, like a blistered surface.

BUTYROUS, growth of a butter-like consistency.

CHAINS,

Short chains composed of 2–8 elements.

Long chains composed of more than 8 elements.

CILIATE, having fine hair-like extensions, like cilia.

CONTOURED, an irregular, smoothly undulating surface, like that of a relief map.

CONVEX, surface the segment of a circle, but flatly convex.

CORIACEOUS, growth tough, not yielding to the platinum needle.

CRATERIFORM, round, depressed, due to the liquefaction of the medium.

CRETACEOUS, growth opaque and white, chalky.

CURLED, composed of parallel chains in strands, as in anthrax colonies.

ECHINULATE, in agar stroke a growth along line of inoculation, with toothed or pointed margins; in stab cultures growth beset with pointed outgrowths.

EFFUSED, growth thin, veily, usually spreading.

ENTIRE, smooth, having a margin destitute of teeth or notches.

EROSE, border irregularly toothed.
FILAMENTOUS, growth composed of long irregularly placed or interwoven filaments.
FILIFORM, in agar stroke a uniform streak along line of inoculation; in stab cultures a uniform growth along line of inoculation.
FIMBRIATE, border fringed with slender processes, larger than filaments.
FLOCOSE, growth composed of short curved chains, variously orientated.
INFUNDIBULIFORM, form of a funnel or inverted cone.
LACERATE, having the margin cut into irregular segments as if torn.
LOBATE, border deeply undulate, producing lobes (see undulate).
MEMBRANOUS, growth thin, coherent, like a membrane.
MYCELIOID, colonies having the radiately filamentous appearance of mould colonies.
NAPIFORM, liquefaction with the form of a turnip.
PLUMOSE, a fleecy or feathery growth.
PULVINATE, in the form of a cushion, decidedly convex.
PUNCTIFORM, very minute colonies, whose form cannot be seen with the naked eye.
RAISED, growth thick, with abrupt or terraced edges.
RHIZOID, growth of an irregular branched or root-like character, as in *B. mycoides.*
RUGOSE, wrinkled.
SACCATE, liquefaction the shape of an elongated sack, tubular, cylindrical.
SPREADING, growth extending much beyond the line of inoculation.
UNDULATE, border waved, with shallow sinuses.
VERRUCOSE, growth wart-like, with wart-like prominences.
VERMIFORM-CONTOURED, growth like a mass of worms, or intestinal coils, as in potato cultures of the potato bacillus.
VILLOUS, growth beset with hair-like extensions.
VISCID, growth follows the needle when touched and withdrawn, sediment on shaking rises as a coherent swirl.

For further terminology see Manual of Determinative Bacteriology, Chester, 1901, pp. 381–86.

This first card and accompanying explanation were almost exclusively the work of Chester, the other two members having made only a few suggestions.[24] While it contained little that was strictly new in principle, it was a decided improvement on what had preceded it. The first two places in the Lawrence group number were rendered superfluous by designating the genera according to the system of Migula, thus restricting the group number to the separation of species. The group number was extended to eight places but the supplementary numbers on the Lawrence card, which were virtually part of the group number, were eliminated. This latter action was not in the line of progress. The need of a method of tersely expressing those characteristics which

[24] Details of the committee action have been kindly supplied by Drs. Gorham and Smith.

are not accepted as being of classificatory rank is evident. The additions under the head of "Detailed Features" was an improvement, a step toward accommodating a complete record of organism upon a single card.

The samples of this card and accompanying folder were distributed to the members some months before the Ann Arbor meeting in December, 1905, and were discussed at that meeting.

The principal objections raised against the first card were the evident inconvenience of consulting data on both sides of the card and the fact that the record of + and — was in the body of the card where it was not easy to make comparisons with other cards. Both of these objections were met in the second society card, which appeared during 1906, and is reproduced in Figs. 8 and 9.

This card was 8 x 10 inches, the increased size allowing all of the data to be placed on one side, the reverse side furnishing the information previously given by an accompanying folder. The arrangement of the headings was also improved, the spaces for the + and — signs being at the margin to facilitate the comparison of a number of cards.

The activities of Professor Chester in this connection practically ceased with this second card, as he went into commercial work and later severed his connection with the society.

When discussed by the society at the New York meeting in 1906, the desire was expressed to have a card sufficiently extensive to accommodate all of the data which should be necessary in describing a new species and at the same time have a provision for emphasizing the points most important in classification. The burden of fulfilling these instructions fell mainly upon Dr. Erwin F. Smith. The result was the 8½ x 10½-inch card adopted by the society at the Chicago meeting. This card is shown in Figs. 10 and 11, the reactions for *Ps. campestris* being indicated to make the form self-explanatory.

This third card, which was indorsed by the Society of American Bacteriologists December 31, 1907, differs from its predecessors in that the group number, brief characterization, detailed features

FIG. 11.—BACK OF THIRD SOCIETY C

DESCRIPTIVE CHART——SOCIETY OF AMERICA

Prepared by F. D. Chester, F. P. Gorham, Erwin F. Smith, Committee on Meth
Endorsed by the Society for general use at the Annual M

Y OF TERMS.

a small block of nutrient agar cut
id placed on a cover-glass, the surface
been first touched with a loop from
or with a dilution from the same.
iown, the same as a hanging drop.
s shapes like an ameba.
ible differentiation in structure.
d, tree-like growth.
disjointed or semi-confluent colonies
ulation.

iable under the platinum needle.
convex prominences, like a blistered

tter-like consistency.

l of 2 to 8 elements.
l of more than 8 elements.
ike extensions, like cilia.
ures which do not contain

ation of casein from whey in milk.
uickly or slowly, and as the result
of an acid or of a lab ferment.
, smoothly undulating surface, like

nt of a circle, but flattened.
a.
gh, leathery, not yielding to the

pressed, due to the liquefaction of

que and white, chalky.
allel chains in wavy strands, as in

e as DIASTATIC, conversion of
le substances by diastase.
oke a growth along line of inoc-
r pointed margins; in stab cultures
ted outgrowths.
unusually spreading.
margin destitute of teeth or notches.
oothed.
mposed of long, irregularly placed
s.
b cultures a uniform growth along

ed with slender processes, larger

sed of short curved chains, va-

MAXIMUM TEMPERATURE, temperature above
does not take place.
MEDIUM, several weeks.
MEMBRANOUS, growth thin, coherent, like a mem
MINIMUM TEMPERATURE, temperature below
does not take place.
MYCELIOID, colonies having the radiately filamen
ance of mold colonies.
NAPIFORM, liquefaction with the form of a turnip.
NITROGEN REQUIREMENTS, the necessary nitro
This is determined by adding to *nitrogen-fre*
nitrogen compound to be tested.
OPALESCENT, resembling the color of an opal.
OPTIMUM TEMPERATURE, temperature at w
is most rapid.
PELLICLE, in fluid bacterial growth either for
tinous or an interrupted sheet over the fluid.
PEPTONIZED, said of curds dissolved by trypsin.
PERSISTENT, many weeks, or months.
PLUMOSE, a fleecy or feathery growth.
PSEUDOZOOGLOEAE, clumps of bacteria, no
readily in water, arising from imperfect se
more or less fusion of the components, but
the degree of compactness and gelatinisati
zoogloeae.
PULVINATE, in the form of a cushion, decidedly
PUNCTIFORM, very minute colonies, at the limi
vision.
RAISED, growth thick, with abrupt or terraced ed
RHIZOID, growth of an irregular branched or root-li
as in *B. mycoides*.
RING, Same as **RIM**, growth at the upper marg
culture, adhering more or less closely to the gl
REPAND, wrinkled.
RAPID, Developing in 24 to 48 hours.
SACCATE, liquefaction the shape of an elongated s
cylindrical.
SCUM, floating islands of bacteria, an interrupte
bacterial membrane.
SLOW, requiring 5 or 6 days or more for developme
SHORT, applied to time, a few days, a week.
SPORANGIA, cells containing endospores.
SPREADING, growth extending much beyond
inoculation, i. e., several millimeters or more.
STRATIFORM, liquefying to the walls of the tub
and then proceeding downwards horizontally.
THERMAL DEATH-POINT, the degree of heat
kill young fluid cultures of an organism exp
minutes (in thin-walled test tubes o
ceeding 20 mm.) in the thermal
must be kept agitated so that t

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...ds of Identification of Bacterial Species.

tri ...leeting, Dec. 31, 1907

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NOTES.

(1) For decimal system of group numbers see Table 1. This will be found useful as a quick method of showing close relationships inside the genus, but is not a sufficient characterization of any organism.

(2) The morphological characters shall be determined and described from growths obtained upon at least one solid medium (nutrient agar) and in at least one liquid medium (nutrient broth.) Growths at 37° C shall be in general not older than 24 to 48 hours, and growths at 20°C not older than 48 to 72 hours. To secure uniformity in cultures, in all cases preliminary cultivation shall be practiced as described in the revised Report af the Committee on Standard Methods of the Laboratory Section of the American Public Health Association, 1905.

(3) The observation of cultural and bio-chemical features shall cover a period of at least 15 days and frequently longer, and shall be made according to the revised Standard Methods above referred to. All media shall be made according to the same Standard Methods.

(4) Gelatin stab cultures shall be held for 6 weeks to determine liquefaction

(5) Ammonia and indol tests shall be made at end of 10th day, nitrite tests at end of 5th day.

(6) Titrate with $\frac{N}{20}$ NaOH, using phenolphthalein as an indicator: make titrations at same times from blank. The difference gives the amount of acid produced.

The titration should be done after boiling to drive off any CO_2 present in the culture.

(7) Generic nomenclature shall begin with the year 1872 (Cohn's first important paper.)

Species nomenclature shall begin with the year 1880 (Koch's discovery of the poured plate method for the separation of organisms.)

(8) Chromogenesis shall be recorded in standard color terms.

TABLE I.

A NUMERICAL SYSTEM OF RECORDING THE SALIENT CHARACTERS OF AN ORGANISM. (GROUP NUMBER)

100.	Endospores produced
200.	Endospores not produced
10.	Aerobic (Strict)
20.	Facultative anaerobic
30.	Anaerobic (Strict)
1.	Gelatin liquefied
2.	Gelatin not liquefied
0.1	Acid and gas from dextrose
0.2	Acid without gas from dextrose
0.3	No acid from dextrose
0.4	No growth with dextrose
.01	Acid and gas from lactose
.02	Acid without gas from lactose
.03	No acid from lactose
.04	No growth with lactose
.001	Acid and gas from saccharose
.002	Acid without gas from saccharose
.003	No acid from saccharose
.004	No growth with saccharose
.0001	Nitrates reduced with evolution of gas
.0002	Nitrates not reduced
.0003	Nitrates reduced without gas formation

and glossary are more extensive. Under brief characterization the record is to be made by + and 0 instead of + and —. The card now provides for all of the observations which are commonly made in connection with bacteria and many of the unusual ones.

It is evident that the present card system of classification is the result of a steady and logical growth and the names of Johnson, Fuller, Conn, Gage, Chester and Smith mark important stages in its progress. While each of them added something of their own they brought much more from the experience of their associates, building gradually the foundations of the science of bacteriology.

CONSTANCY OF THE BASIS FOR THE GROUP NUMBER.

While the group number, brief characterization and detailed description, as previously described, are all important, the maximum weight attaches to the group number, since this is the basis upon which the collections of cards are arranged. Any variation in this number, in the case of strains of the same species, will separate the representatives of this species.

As already stated the species selected for this study was *Pseudomonas campestris* (Pam.) Smith, a well-known, chromogenic, plant pathogen; since with this species the question of contamination could be easily settled.

Variations in bacteria are sometimes ascribed to the differences in climate and food in nature. In order to observe the result of varied climatic environments cultures were kindly provided by Prof. S. A. Beach from Iowa, Prof. W. J. Morse from Maine, Prof. F. L. Stevens from North Carolina and Dr. Erwin F. Smith from Washington, D. C., in addition to a large number of cultures isolated from widely separated points in this State.

When the group number was determined in accordance with the directions prepared by the Society of American Bacteriologists the group number 211.3332513 was identical for all of these cultures.

Although difference in natural environment between points separated by more than a thousand miles was evidently not sufficient to affect these physiological reactions of this species it is conceivable that the vicissitudes of moisture and of food to which artificial cultures are exposed might be more potent in this connection. Accordingly comparisons were made between the group number of cultures freshly isolated from diseased cabbage and that of cultures which had been long in cultivation in this and other laboratories. This observation of the effect of cultivation in this laboratory covered sixteen months. Some of the cultures had, at the beginning of this period, been cultivated for months if not years, while others had been freshly isolated from the diseased plants.

The group numbers obtained for these various strains, with certain exceptions to be later discussed, were identical, strongly indicating that artificial cultivation does not induce changes in the group number of this species.

In presenting the results of this study the fact that there were some apparently discordant observations should not be overlooked. It is highly probable that the common conception of the variability of bacteria is largely due to such discordant observations which have not been traced to their true causes.

In shipping cultures through the mail where they are exposed to the curiosity of the mail clerks, in the exposure accompanying the repeated transfer of stock cultures and in selecting typical colonies as a basis for stock cultures from plates, either in isolation from diseased plants or in the revivifying process, there is a constant opportunity for contamination and mistakes in judgment. Only the most careful attention to details will detect all of these contaminations.

In this study, including over 50 strains, there were five cases where the group number was determined for cultures which had the gross appearance of *Ps. campestris* in colony growths but a detailed study showed that they were not this organism.

There were two additional cases of discordant observations which could not be so easily explained. A culture of our own isolation, strain 3, after being cultivated in the laboratory for eight months produced a faint acidity in fermentation tubes containing respectively lactose, saccharose and glycerin. Two months later this same strain, tested on cabbage in the green-house, produced the typical black rot. A culture reisolated from one of these diseased plants, strain 80, did not give the above anomalous acid reaction with lactose, saccharose and glycerin but gave the typical group number. It was not possible to determine more closely the cause of these unusual reactions with strain 3 since it had been accidentally lost. This may have been a true case of variation but the failure of the acquired fermentative ability to persist in the culture reisolated from the diseased plant would suggest that the original group number determination was confused by the presence of an undetected acid-forming contamination which was excluded by passing the culture through the cabbage plant.

Acid formation was also observed with strain 65, which was isolated from diseased cabbage from Long Island. After being cultivated two months in the laboratory it was inoculated into cabbage in the green-house and gave no outward evidence of pathogenicity. On dissecting the plants a few blackened bundles were found close to the point of inoculation in one plant and reisolations from these bundles gave strain 98. A determination of the group number of each strain now showed the formation of acid in the presence of dextrose, lactose, saccharose and glycerin with each, a reaction which is not typical of *Ps. campestris.*

Immediately after these determinations strain 98 was inoculated into three cabbage plants in the field with the usual precautions, the inoculation being made through the base of a severed leaf, the point of inoculation being carefully covered with sterile, melted, grafting wax and suitable check inoculations being made on adjoining plants at the same time. Each of three plants thus

inoculated with strain 98 developed a well-marked case of black rot while the adjoining check plants remained healthy. The disease began at the point of inoculation and was traced by the blackened fibro-vascular bundles into a large number of the leaves. Cultures made from these blackened bundles, several inches from the original point of inoculation, gave an apparently pure culture, strain 100. The group number of this strain was typical, there being no evidence of acid formation from any of the sugars or from glycerin.

From a superficial observation of these results with strains 65, 98 and 100 one might conclude that here was an acquisition and later a loss of the ability to form acid, corroborating the observations with strains 3 and 80. This view is strengthened by the retention of this acid-forming character after passage through one cabbage plant even though this ability was lost in passing through the second plant.

A careful study of these observations shows that the above idea has really little basis in fact and that these apparently discordant observations were probably due to unrecognized contaminations.

The strongest evidence against the idea of contaminated cultures is the appearance of this acid-formation in two strains, 65 and 98, the latter after the passage of the culture through a cabbage plant. However, in this case there were no lesions produced except a blackening of the fibro-vascular bundles at the point of inoculation and the material for strain 98 was necessarily taken from practically the point where strain 65 was inoculated. Russell[25] showed that even ordinary saprophytes are able to survive at the point of inoculation in plants for some months so that in this case the survival of a mixed culture is neither impossible nor improbable. On the other hand when strain 98 was inoculated into cabbage it produced an extensive disease so that the material from which strain 100 was derived came from a distant portion of the plant and the contamination present in the inoculating material was thus mechanically removed.

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[25] Russell, H. L. Bacteria in their relation to vegetable tissue. From Johns Hopkins Hospital Reports, 3: 223–263. 1893.

If we consider more closely the fermentation tube tests of strains 3 and 80 and strains 65, 98 and 100 it will be noticed that strain 3 did not form acid from dextrose while strains 65 and 98 formed acid from this sugar. Also the formation of acid from various substances by strain 3 was not accompanied by any growth in the closed arm while with both strains 65 and 98 this growth was abundant under such circumstances. Thus if the ability to form acid is to be considered as an acquired characteristic of strains 3 and 65 it is evident that in the two instances this ability was acquired with regard to different sugars and further in the latter case the relation to oxygen was also profoundly modified. In strain 100, both of these modifications had been lost.

Fortunately strains 65 and 98 were available for study although seven months had elapsed since the previous test. At this time strain 65 was less chromogenic although it gave the reactions with fermentation tube tests which are recorded for the original strain 65. On the other hand strain 98 was typically chromogenic, did not grow in the closed arm of the fermentation tubes and did not form acid from the sugars or glycerin. The repeated transfers of the stock cultures had resulted in a pure culture of the contamination, which was a bacillus with the group number B. 211.2223532, on one hand and of the true *Ps. campestris* on the other.

The observations on nitrate reduction were the occasion of some confusion during the earlier determinations. Where the cultures were tested for the presence of nitrites by the official sulphanilic acid method there was at times a faint reaction for nitrites which seemed more marked than the reaction obtained from the control tubes. This method of detecting nitrites is so delicate that the nitrites ordinarily absorbed by the control tubes give a faint reaction. When a large number of control tubes were tested, the intensity of the color was not the same in all of the tubes, even when originally filled from the same flask of media. Accordingly when testing a large number of inoculated tubes with

a small number of controls it was probable that some of the inoculated tubes would give a stronger reaction than the controls.

A large number of cultures were prepared, using all of the strains where nitrate reduction had been previously recorded, and comparative tests were made, after the proper interval, by the official sulphanilic acid and by the $KI–H_2SO_4$– starch[26] methods. In these tests both the control tubes and a number of the inoculated ones gave irregular results by the official method but in no case was there the slightest evidence of nitrite formation by the $KI–H_2SO_4$– starch method. Although the sulphanilic acid method is official it is evident that it is too delicate for satisfactory results where media are kept for a number of days in an ordinary laboratory.

It will be observed that this failure to reduce nitrates is not in agreement with the reaction indicated by the illustrative group number of *Ps. campestris* as given on the official card. However Dr. Erwin F. Smith[27] states that this number on the card is a typographical error and not in accord on this point with any previous data.

Varying results are to be expected in the test for the diastatic action of the organism on potato starch, since the official methods do not set time limits nor prescribe methods for making the test. In this study the cultures were made on potato cultures in large test tubes, containing a supply of water and the starch test applied after two weeks. For this purpose an alcoholic solution of KI–I was added separately to the water in the culture tube and to the potato mass after crushing in water. A faint action on the starch is shown by a wine color in the water in the culture tube where such action would pass unnoticed with the potato mass. Naturally the extent of the diastatic action turns both on the age and vigor of the culture used. The action was always well marked and often practically complete after two weeks.

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[26] The details of this method are given by Smith, E. F. Bacteria in relation to plant diseases. Vol. I, p. 63. 1905.
[27] In a personal letter.

CONSTANCY OF "BRIEF CHARACTERIZATION" ITEMS.

The present application of the Society Card to classification is primarily in connection with the group number. However, as has been pointed out by Bergey and Bates,[28] it will undoubtedly be necessary to extend this number to additional reactions before the group number will separate bacteria down to the groups which we ordinarily designate as species. In searching for suitable reactions to be used in this connection attention turns first to those items included under "Brief Characterization." Constancy in the results of tests with different strains of the same species is the important point in this connection and accordingly observations on many of the headings given on the card under brief characterization were made when the group number was being determined.

The results of these observations are given in Table I.

[28] Bergey, D. H. and Bates, H. L. The numerical classification of bacteria. From the Univ. of Pa. Medical Bulletin. July, 1906.

TABLE I.—ACTION OF STRAINS OF P. CAMPESTRIS WITH RESPECT TO "BRIEF CHARACTERIZATION" ITEMS.

Source:	No. of Strain	Months in Lab.	Plant pathogen, epiphyte	Indol ( )	Milk			Liquefaction			Grows in Uschinsky's Sol.	Grows in Cohn's Sol.	Potato				Gel. Stab		Gel. Plate.					Agar				Broth			
					Casein peptonized	Rennet curd	Acid curd	Agar	Casein	Gelatin (4)			Starch destroyed	Discolored	Abundant	Moderate	Needle-growth	Surface-growth	Curled	Filamentous	Rhizoid	Proteus-like	Round	Chromogenic	Wrinkled	Dull	Shining	Sediment	Pellicle	Ring	Cloudy, turbid
Geneva..........	3	8	+	0	+	+	+	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	0	+
Iowa..........	4	7	+	0	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
Geneva..........	6	8	+	0	+	+	0	0	+	+	0	0	+	..	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	0	0
"	8	8	+	0	+	0	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	0	+
"	12	8	+	0	+	+	0	0	+	+	0	0	+	0	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	13	8	+	0	+	+	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	13	14	+	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
"	14	8	+	0	+	+	0	0	+	+	0	0	+	..	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	15	11	+	0	+	0	0	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	16	8	+	0	..	+	0	0		+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
"	16	14	+	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
Long Island.....	19	10	+	0	+	+	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
"	19	16	+	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
"	20	15	+	0	+	+	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
"	25	12	+	0	+	0	0	0	+	+	0	0	+	..	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
Maine..........	31	1	..	0	+	+	0	0	+	+	0	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	..	+	..	+
"	31	3	0	0	+	0	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
Washington.....	34	4	+	0	+	..	..	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
Geneva..........	35	4	+	0	+	..	..	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	39	..	..	0	+	..	..	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	40	..	..	0	+	..	0	0	+	+	0	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	40	..	0	0	+	0	0	0	+	+	0	0	+	+	0	+	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
North Carolina..	45	..	..	0	+	0	0	0	+	+	0	0	+	+	+	0	+	+	..	..	..	..	..	+	0	0	+	+	+	+	+
Long Island.....	50	0	+	0	+	+	0	0	+	+	0	0	..	..	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	50	7	..	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
"	51	0	+	0	+	+	0	0	+	+	0	0	..	..	..	..	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	52	7	..	0	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
"	52	0	..	+	+	+	0	0	+	+	0	0	..	..	..	..	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	53	0	..	0	+	+	0	0	+	+	0	0	..	..	..	..	+	+	..	..	..	..	..	+	0	0	+	..	..	..	..
"	53	7	..	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	+	+
"	54	0	..	0	+	+	0	0	+	..	0	0	..	..	+	0	+	+	..	..	..	..	..	+	0	0	+	+	0	+	+
"	54	7	..	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	+	+
"	55	3	+	0	+	0	0	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	60	3	+	0	+	0	0	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
"	65	3	+	+	+	..	..	0	+	+	+	+	+	..	0	+	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
No. 3..........	80	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 4..........	81	0	0	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 6..........	82	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 8..........	83	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 12..........	84	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	0	0	0	+
" 13..........	85	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 14..........	86	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 15..........	87	0	+	0	+	0	0	0	+	+	+	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 16..........	88	0	+	0	+	+	0	0	+	+	+	+	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 19..........	89	0	+	0	+	0	+	0	+	+	0	0	+	+	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 50..........	90	0	+	0	+	0	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	0	0	+
" 32..........	92	0	+	+	+	0	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 34..........	93	0	+	0	+	0	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 35..........	94	0	+	0	+	+	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 55..........	96	0	+	+	+	0	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 60..........	97	0	+	..	+	+	0	0	+	+	+	0	+	..	+	0	+	+	0	0	0	0	+	+	0	0	+	+	+	..	0
" 65..........	98	0	+	+	+	..	..	0	+	+	+	+	+	..	0	+	+	+	0	0	0	0	+	+	0	0	+	+	+	..	+
" 98..........	100	3	..	..	+	+	0	0	+	+	0	0	+	0	+	0	+	+	0	0	0	0	+	+	0	0	+	0	0	+	+

These results are arranged in the order of the serial numbers of the strains, a positive reaction being indicated by +, a negative by 0 and the lack of data by . . .

Months in the laboratory.— It will be noted that determinations of strains 50–54 and 80–98 were made promptly after they had been isolated from diseased material. Accordingly these determinations represent *Ps. campestris* when showing the minimum effect of artificial cultivation. The maximum effect of such cultivation here shown is sixteen months in the case of strain 19. Aside from the cultures which were obtained from other laboratories and concerning the previous history of which little is known, the numerals in this column indicate the period during which the strains had been cultivated previous to having their characteristics determined. A second determination after an interval was made in the case of strains 13, 16, 19, 31, 40, 50, 52, 53 and 54.

Pathogenicity.— This was determined by inoculations from forty-eight-hour agar slopes into young, rapidly growing cabbage plants in the green-house, inoculating through the base of a severed leaf by means of a sterilized platinum needle dipped in the culture, the inoculation being covered with sterile melted grafting wax. Similar check inoculations were made at the same time using the same sterile platinum needle and other untreated plants were also retained in connected with the inoculated plants in the green-house. The first evidence of disease usually appeared in about ten days, showing as blackened veinlets in the lamina of one or more leaves above the point of inoculation. In all of these tests no disease appeared in any of the check plants or in the untreated controls. There is a common impression that the pathogenicity of bacteria toward plants is an extremely variable matter. These results show only three failures of pathogenicity to manifest itself out of forty-one tests, notwithstanding the fact that a large part of these strains had been cultivated eight months or more before being tested. On the other hand it is true that the degree of pathogenicity is somewhat variable. Inoculations

were made in triplicate on the same day, using cabbage plants which had grown from seed sown on the same day, inoculating from agar slopes of the same age and composition. With some strains disease was evident in all three plants in ten days while others presented lesions only after three weeks. The basis of this variation is not yet recognized but probably lies in faulty technique, the cultures not being brought to standard conditions in some particular before the inoculations are made.

Indol.— Five strains are recorded as positive at a single examination. Strain 52 was negative seven months later and evidence has already been presented to show that strains 65 and 98 were contaminated when tested. The indol formation has not been redetermined for strains 92 and 96. In no case was there evidence of strong indol formation but with a number of other strains single tubes in the triplicate test gave faint indications of indol formation. The tests were made at the end of ten days by adding two drops of concentrated sulphuric acid and 1 c.c. of a 0.01 per ct. solution of sodium nitrite to the culture in 1 per ct. peptone water, taking the color reading at the end of thirty minutes.

These results would indicate that the tendency to indol formation is stronger in freshly isolated cultures and that a careful study of the causes of this variation should precede the adoption of indol formation as a basis of classification.

Casein peptonized.— The results are all positive since *Ps. campestris* is an active digester. The lack of a simple and accurate test of the beginning of digestion limits the usefulness of this reaction with many organisms. A search for such a test should include a consideration of both Hasting's[29] work and a chemical determination of the digestion products either with or without dialysis.

Rennet and acid curd.— Milk was frequently digested by this species without any apparent curdling. As acid was absent, except in a single instance, the curdling which occurred was at-

[29] Hastings, E. G. The action of various classes of bacteria on casein as shown by milk-agar plates. *Cent. f. Bak.* II, 12: 590–592. 1904.

tributed to rennet. The distinction between rennet and acid curds is not sufficiently clear cut to be of much value in classification.

Liquefaction.— The liquefaction of agar, while not unknown, is so rare as to be of little use as a distinguishing characteristic. Liquefaction of casein has been already discussed. Gelatin was uniformly liquefied but the rate of action varied widely. This action is recorded in the group number.

Uschinsky's solution.— The solution used had the following composition:

30.0	grams	glycerin	$C_3H_5(OH)_3$
5.0	"	sodium chloride	$NaCl$
0.1	"	calcium chloride	$CaCl_2$
0.3	"	magnesium sulphate	$MgSO_4$
6.0	"	ammonium lactate	$(NH_4)\ C_3H_5O_3$
2.0	"	di-potassium phosphate	K_2HPO_4
3.0	"	sodium asparaginate	$NaC_4H_6O_4$
1000	cc.	distilled water	

Growth was evident with approximately one-half of the strains and slight multiplication undoubtedly occurred with at least a part of the remainder.

Cohn's solution.— This solution had the following composition:

5.0	grams	acid potassium phosphate	KH_2PO_4
5.0	"	magnesium sulphate	$MgSO_4$
10.0	"	neutral ammonium tartrate	$(NH_4)_2C_4H_4O_6$
0.5	"	potassium chloride	KCl
1000	cc.	distilled water	

This solution was much less acceptable to *Ps. campestris* than the Uschinsky's solution, growth being evident with only 11 strains. When this determination was repeated with strains 31 and 40 the growth did not appear showing that even with the same strain the results were quite variable.

This marked irregularity in growth in these two solutions of known composition does not favor the idea that the use of syn-

thetic media is the true basis for exact comparative work. There seems no escape from the conclusion that there was some unrecognized factor which produced this variation and it is quite possible that were this recognized constant results might have been obtained.

Potato.— The starch was regularly attacked as described under group number. Beyond the limit of the visible growth the surface of the potato was rendered gray. At one stage of the culture a white margin or halo was formed just outside of the line of growth and this is indicated in the table by +. This was probably present in all cases but as this was a transient phenomenon it was not always recorded. The growth appeared quickly at 20–30°C. and soon became abundant in all but strain 98. Ordinarily the growth flowed from the potato to the bottom of the container within ten days.

Gelatin stab.—Although this species is so strong an aerobe that growth does not appear in the closed arm of the fermentation tube it uniformly takes place along the needle track. Surface growth is also always present. These two reactions, needle-growth and surface-growth, are of little value for classification not because they are variable but rather because practically all species agree in these particulars.

Gelatin plate.— In this division all of the strains agree in that the colonies are round. While other forms of colonies occur with a few species such species are very unusual. Moreover form of colony is so largely dependent on environment that it has little value for classification.

Agar.— The results under this head are entirely accordant, the cultures being yellow and shining. The color is a part of the group number. While no confusion would arise with this species from the use of the surface appearance for classification other species would undoubtedly be found where the record on this point would depend largely upon the personal equation.

Broth.— This species develops a finely granular turbidity and later forms a sediment but the turbidity was not noted with

strains 6 and 97 and the sediment was lacking with strains 84 and 100. Ring and pellicle formation were very irregular, each appearing with about one-half of the strains.

These results would indicate that data of value for classification might be obtained from pathogenicity to plants, indol formation, casein digestion, growth in Uschinsky and Cohn solutions and turbidity in broth. In all cases further study both of the technique of making tests and of the reactions of different species will be necessary before the relative constancy of these reactions can be settled.

CONCLUSIONS.

The present Classification Card of the Society of American Bacteriologists is the logical outcome of forces which have been at work among bacteriologists for at least fifteen years.

This card offers a basis for classification which in convenience of application and in certainty of result surpasses anything which has preceded it. In furnishing a form for recording and organizing a mass of observations it solves a difficulty which has frequently been the limiting factor in research. Intelligently applied it is calculated to bring order out of chaos and thereby become a most potent factor in raising bacteriology to the dignity of a true science.

When tested upon forty-four strains of *Pseudomonas campestris* (Pam.) Smith, the group number, as now constituted, gave constant results and did not break the species into smaller groups. Therefore so far as it applies to this species it is a satisfactory basis for classification. This study did not test the possibility of other species having this same group number.

The qualitative variations and apparently discordant reactions which have commonly been attributed to bacteria are probably due largely to faults either in observation or in technique. Quantitative variations are constantly met but these in turn are undoubtedly largely due to lack of knowledge concerning the proper revivifying process to be applied before determining the culture characteristics.

THE MODERN MILK PAIL.*

H. A. HARDING, J. K. WILSON AND G. A. SMITH.

SUMMARY.

1. More than one-half of the infection that milk receives during the milking process can be prevented by the use of a covered pail.

2. A covered pail which is less than twelve inches high and is provided with an elliptical opening seven by five inches is practically as convenient for milking as an ordinary pail. Such a cover can be placed upon an ordinary milk pail by any tinsmith at very little expense.

3. Such a pail is inexpensive, durable, easily cleaned and one of the most effective in keeping bacteria out of the milk.

*A reprint of Bulletin No. 326.

INTRODUCTION.

The most striking of the recent changes in dairying is the increasing consumption of milk by the cities. Along with this increased consumption of raw milk there has arisen a demand for a cleaner and more sanitary article. This demand has shown itself by a growing system of municipal inspection of the conditions of production and transportation, by an increasing desire for a tuberculin test of milch cows and by at least a limited demand for high-priced "certified" milk.

In meeting this demand for cleaner milk, which too often is not accompanied by the offer of an increase in price, the producer must consider the relative cost of the various avenues of improvement which are open to him. If wise he will first utilize those which will give the greatest gain for the least outlay in time and money.

The shape and construction of the milking pail is probably of first importance in this connection; and this bulletin gives the results of comparative tests of a number of improved pails that are upon the market. It also suggests a form which combines the good points of the best pails and one which can be easily and cheaply made by any tinsmith.

THE GRADUAL IMPROVEMENT OF THE MILK PAIL.

The milk pail of two generations ago was commonly of wood with slightly flaring sides, but this has been gradually supplanted by a metal pail of the same general form. The change was largely due to the greater durability and less cost of the metal pail, though it was hastened by the gradual recognition of the difficulty of properly cleansing wooden pails. At present these flaring-sided, wide-topped pails (Plate I, fig. 1) are in use in practically all of the ordinary dairies, the improved pails having as yet been adopted in only a few of the more progressive ones.

Mention should be made of the so-called "strainer pail" which was used in a limited way twenty to forty years ago. This was an ordinary metal pail with a cover over one-half or less of the top. During the milking process this cover partly protected the contents of the pail, and the milk was strained by pouring out through a section of closely woven wire cloth soldered into one side of the cover. As dairying developed it was found that this form of strainer was not efficient and the strainer pail has practically disappeared.

Recognition of the large amount of contamination which normally occurs during the milking process is of long standing. All observing milkers have noticed that the foam which rises on the milk gradually becomes darker as the milking proceeds, due to foreign matter falling into it. In 1892 Dr. H. L. Russell at Wisconsin was appointed as the first official bacteriologist at an American agricultural experiment station. This appointment was due to a growing public interest in the relation of bacteria to the dairy, an interest which had been much stimulated by the work of Dr. H. W. Conn at Wesleyan University, who became affiliated with the Storrs Agricultural Experiment Station in 1890. In one of his first contributions to agricultural literature Russell[1] pointed out that this foreign matter falling into the pail during the milking process introduced a large number of bacteria and these in turn impaired the keeping quality of the milk.

A factor which has largely increased the demand for an improved milk pail is the Medical Milk Commission and the resulting production of "certified" milk. The first of these commissions was organized at Newark, N. J., April 13, 1893, under the leadership of Dr. H. L. Coit.[2] Associated with this commis-

[1] Russell, H. L. The source of bacterial infection and the relation of the same to the keeping quality of the milk. Wis. Agr. Exp. Station Ann. Rpt. 11 (1894): 150–165. 1895.

[2] Coit, Dr. H. L. The origin, general plan, and scope of the medical milk commission. *Amer. Asso. of Med. Milk Comm. Proc.* 1 (1907): 10–17. 1908.

sion from its organization, as bacteriologist, was Dr. R. G. Freeman. He states:[3]

"One of the first experiments I made when I undertook the duties of bacteriologist to Dr. Coit's original milk commission (1893), in order to ascertain the source of bacteria in milk, was to expose simultaneously three petri-plates, one out of doors, one in a barn, and one under the udder of a cow during milking. By these experiments I demonstrated to my own satisfaction that the bulk of the bacteria in milk were shaken from the udder of the cow during milking, and this showed me the necessity of a pail with the opening in the side instead of in the top; that is, a hooded pail.

"I immediately (1895) tried to get Mr. Francisco to use such pails in his dairy. They were tried, but without real earnestness, and were rejected. I then attempted to have the same pail used at the Walker-Gordon Farm at Plainsboro, and at one time when there was an annual meeting of the directors twelve of the pails were put in use and were also rejected as impracticable.

"My first encouragement was two years later, when in visiting Mr. Shoemaker's beautiful farm near Baltimore, I found that he had ordered such pails for his dairy, after seeing them at Plainsboro, and he had had them in use during the two years, finding them of great advantage.

"After this it was easier to have them adopted in other places, and at the present time all the pails at the Walker-Gordon Farm are hooded, and I believe the same is true at Mr. Francisco's although the type used is somewhat modified."

The first reference in print[4] to this pail is as follows:

"Milk pails of the ordinary type should not be used. A special pail with the top partially covered and having an opening in the top only eight inches in diameter diminishes considerably the amount of dirt which falls into the pail during milking. Or, a pail with a hood attachment in which the opening is practically in the side is practicable for use and will give still greater protection."

At first this hood was made as a separable part which could be slipped off or on at will, but later it was made as an integral part of the pail. Perhaps the most acceptable form of Freeman pail is shown in Plate I, fig. 2, while a less desirable form is shown in Plate I, fig. 3.

While the best type of the Freeman pail carried the matter of reducing the opening to its practical limit, it placed some hin-

[3] Letter of October 4, 1910.

[4] Article by Dr. R. G. Freeman in *Sea-Side Times*, Southampton, N. Y., March 17, 1898.

drance in the way of thorough cleaning and paid little attention to the important matter of convenience in actual milking. One farmer described the use of one of these pails as "A good deal like milking into a jug."

A second type of improved milk pail is the "Gurler" (Plate II, fig. 1. Of it, Mr. H. B. Gurler of De Kalb, Ill., writes[5]: "I can not remember the exact date that I commenced to use it (the Gurler pail), but it was soon after I embarked in the Certified Milk business in 1895." This was early a popular form and is still used in some of the best dairies.

The work of Conn bore fruit in stimulating Mr. F. H. Stadtmüller[6] of West Hartford, Conn., to devise another type of successful, small-topped milk pail, with a 3⅝-inch opening (Plate II, fig. 2). Into this pail the streams of milk entered through a metal-and-cloth strainer. This pail was first used by him in 1897. It was in daily use for some years at the Storrs Agricultural Experiment Station and its efficiency was critically studied by Stocking.[7] This was probably the earliest extensive study of the relation of the covered pail to the bacterial content of the milk, although bacteriological work on this subject had been done much earlier by Freeman and by Conn.[8] Stocking contrasted the results obtained from the use of the Stadtmüller pail and mechanical strainer with those obtained with the ordinary open-topped pail. He found that the improved pail kept out 63 per ct. of the dirt but only prevented the entrance of 29 per ct. of the bacteria. It was evident that many of the bacteria in the dirt falling upon the strainer were washed out into the pail by the milking process. As the result of an increased knowledge of sanitary milk production the mechanical strainer and cloth were later omitted. This type is represented in the present study by the Newburgh pail (Plate II, fig. 3) which is essentially an improved Stadtmüller pail.

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[5] Letter of August 8, 1910.

[6] Letter of December 12, 1910.

[7] Stocking, W. A., Jr. Efficiency of a covered pail in excluding filth and bacteria from milk. Storrs Agr. Exp. Station Ann. Rpt. 14 (1901). 105–121, also Bul. 25. 1903.

[3] Letter of F. H. Stadtmüller, Dec. 12, 1910.

Of the multitude of milk pails which have been devised, these three early types are all that have attained any considerable measure of success. The Stadtmüller and Gurler pails originally provided for a mechanical straining of the milk before entering the pail. The object was to keep the filth out of the milk. Unfortunately the collecting of the foreign matter on the strainer subjected it to the vigorous action of the streams of milk and by the close of the milking the greater part of the bacteria and the finer particles of filth had been so thoroughly incorporated with the milk that their later removal was practically impossible. Again, the constant supply of new absorbent cotton or cloth, as a straining medium, was an item of continual expense; while the cloths, if used repeatedly and with such care as they would ordinarily receive, were a greater source of contamination than the filth they were designed to exclude. When it was recognized that the evil effects of dirt in milk were due to the bacteria which the dirt carried and that the mechanical strainers might introduce more bacteria than they removed with the dirt it was seen that the main value of these improved pails lay in the decreased opportunity for dirt and bacteria to enter through the diminished openings at the top.

The principle of the Freeman pail, the modification of the size and location of the free opening so as to prevent the entrance of the larger part of the bacteria, has been generally accepted. On the other hand Freeman pails are extreme both in height and in smallness of opening. These objections were successfully met in the "Trueman"[9] or as it is now called the "Storrs"[10] pail. (Plate III, fig. 1.) This was devised by Prof J. M. Trueman as a modification of the Freeman pail and was first used during the summer of 1907. The "Loy" pail (Plate III, fig. 2), is practically a duplicate of the Storrs pail and was devised independently in 1908 as a modification of the Freeman pail by Mr. Harry Loy, a Geneva tinsmith. The continued use of this pail

[9] Esten, W. M., and Mason, C. J. Sources of bacteria in milk. Storrs Agr. Exp. Station Bull. 51, p. 72. 1908.

[10] Letter of August 4, 1910, from Prof. J. M. Trueman.

has indicated the desirability of some slight modifications as shown in Plate III, fig. 3.

PREVIOUS STUDIES.

The earliest publication of Prof. W. A. Stocking has already been noticed.[11] He later conducted a comparative study of the Stadtmüller, Haymaker, North and Gurler pails, testing them with and without the presence of their straining devices. This study was carried on both at the Storrs Station barn and at two other dairies where the conditions were less favorable for the production of clean milk.

He concluded that[12] " the use of a covered pail is of great advantage in any stable in excluding dirt and bacteria from the milk. The relative advantage gained by the use of the cover depends upon the sanitary condition of the stable. (The dirtier the cows the greater the relative gain.) The special form of cover does not seem to be important provided it is a device practical for use, and the area through which the dirt can gain access to the milk is reduced as much as possible.

" Whether or not a strainer on the covered pail is desirable depends upon the style of the straining device. The use of a strainer in a pail where the dirt which falls into the opening is likely to be driven through by the succeeding streams of milk is not desirable. Its use tends to increase the germ content of the milk and injure its keeping quality."

PRESENT STUDY.

In these experiments the attempt has been made to determine the effect, on the germ content, of using various improved pails. In doing this care has been taken to exclude all other factors as fully as possible and to so arrange the tests as to equalize those which could not be excluded.

GENERAL CONDITIONS.

Care was exercised to have the barn and the cows in as clean a condition as could be steadily maintained under good dairy

11 See footnote 7.

12 Stocking, W. A., Jr. Comparative studies with covered milk pails. Storrs Agr. Exp. Station Bul. 48. 1907; also, Ann. Rept. 19: (1907): 77–103.

management and to make tests only when these conditions seemed to be normal. For this reason the tests were restricted to the evening milking, when such conditions could be better controlled.[13]

In the test of each pail except the Gurler four cows were chosen which were in an average flow of milk, and each evening two cows were milked into standard 12-inch pails and two into the kind of pail being studied. Cows were rejected which were unusual either in their individual habits of uncleanliness or in the shagginess of their coat, those used being short haired Jerseys or Jersey grades. While it was necessary to utilize a number of milkers during this study and they exerted an influence upon the germ content of the milk, this factor was equalized by having one individual, as far as possible, milk a given cow during the entire test of any one pail.

Under these conditions of milking, when the final germ content is low, the bacteriological count is often markedly influenced by the bacteria of the milk in the udder. In order to equalize this factor each cow was milked, on successive evenings, into the standard open pail and into the pail to be tested. The validity of this equalization rests partly upon the assumption that the germ content of a given udder is approximately constant during succeeding days and partly upon the assumption that during ten successive milkings the variations which existed would tend to equalize each other.

The pails, in addition to being thoroughly washed, were exposed to live steam in a steam box for 5 to 8 minutes shortly before being taken to the barn for use. Up to the moment they were used in milking they were protected from contamination by cheese cloth which was tied over them before they were placed in the steam box. A pail freshly steamed and protected in this manner was used in the milking of each cow. Thus the germs in the milk were derived from only two sources, the germs in the udder and those in the dirt which fell into the pail during the milking process.

As soon as the milking of a cow was completed the pail was taken to the adjoining milk room, the milk was thoroughly mixed

13 The details of the barn management are given in Bulletin No. 317 of this Station.

with a sterile, long-handled spoon and a sample transferred from the pail to a sterile test tube.

TECHNIQUE.

The samples were taken to the laboratory and promptly plated, the entire process being completed within an hour from the taking of the first sample. Plates were prepared on medium 3.20 which has the following composition:

5	grams	NaCl.	
15	"	Agar.	
10	"	Peptone (Witte)	Reaction 1.5 per ct. normal
10	"	Lactose	acid to phenolphthalein.
5	"	Beef extract (Liebig)	
1000	cc.	Water (distilled)	

In the preliminary work four plates were made from each sample using dilutions 1:100, 1:250, 1:500; later the dilutions were 1:10, 1:20, 1:50 and 1:100; finally but three plates were made, using the dilutions 1:10, 1:20 and 1:50. In one series of comparisons 1 cc. of milk was divided among four plates, the sum of the colonies observed in the four plates giving the content per cubic centimeter.

The plates were counted after they had remained five days in a room ranging in temperature between 20 and 24°C. with a mean temperature of 23°C. Frequent recounts at the end of eight days, at the room temperature, did not show an increase in the number of colonies. Toward the close of this work when plates that had been five days at room temperature were held two days at 37°C., many of them gave a markedly higher count, though this increase was not found in all plates. In all cases the counting was done with a hand lens magnifying four diameters, and the counts given are those for five days at 20–24°C.

DILUTIONS.

The first point to be determined was the dilutions which would give the most satisfactory results. With the ideal dilution for quantitative work the colonies are not so crowded as to interfere

with growth and yet are sufficiently numerous to give accordant results. Ordinarily plates with 250 to 500 colonies are considered best for such work. On account of the wide variation in germ content in fresh milk a fairly wide range of dilutions is necessary. The dilutions first tested were 1:100, 1:250, 1:500 and 1:1000.

The results with these dilutions when contrasting the Freeman with the ordinary 12-inch pail are given in Table I.

TABLE I. THE RELATION OF DILUTION FACTOR TO BACTERIOLOGICAL COUNT OF MILK.

HAMMOND NO. 2, MILKED BY W.

1908	FREEMAN PAIL DILUTION— 1:100	1:250	1:500	1:1,000	1908	OPEN PAIL DILUTION— 1:100	1:250	1:500	1:1,000
	Per cc.	*Per cc.*	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*
Nov. 16	1,500	2,250	3,000	3,000	Nov. 17	12,500	14,000	14,000	20,000
	300	1,250	500	3,000		10,500	10,500	8,000	7,000
18	900	1,250	3,500	3,000	19	2,800	3,000	4,000	4,000
						2,400	1,750	500	2,000
Av.	900	1,583	2,333	3,000		7,050	7,312	6,625	8,250

ANNIE G, MILKED BY W.

17	103,800	176,000	105,000	102,000	16	1,700	2,000	2,000	3,000
	105,600	163,560	126,000	180,000		2,100	3,600	4,500	6,000
19	300	1,250	1,000	1,000	18	3,100	3,000	3,500	2,000
	1,500	1,500	500	3,000		2,500	4,000	2,500	3,000
Av.	52,800	85,575	57,875	71,500		2,350	3,150	3,125	3,500

CAREY'S F, MILKED BY B.

					16	3,800	3,500	3,000	5,000
17	900	2,000	1,500	0		3,900	3,000	4,000	4,000
	1,000	750	1,500	1,000					
						1,400	1,250	500	3,000
					18	1,000	750	500	0
					19	1,200	1,250	1,500	0
						100	500	0	0
Av.	950	1,375	1,500	500		1,900	1,708	1,583	2,000

TABLE I. THE RELATION OF DILUTION FACTOR TO BACTERIOLOGICAL COUNT OF MILK — (*Continued*).

DOTSHOME CAREY, MILKED BY B.

1908	Freeman Pail — Dilution— 1-100	1-250	1-250	1-1,000	1908	Open Pail — Dilution— 1-100	1-250	1-500	1-1,000
	Per cc.	*Per cc.*	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*
Nov. 16	600	1,750	2,000	5,000	Nov. 17	100	250	500	0
	600	*......	2,000	3,000		500	0	0	0
18	100	250	1,500	0					
	300	0	500	0					
19	400	500	1,000	1,000					
	200	500	500	0					
Av.	366	600	1,250	1,500		300	125	250	0

* Plates moldy.

It is seen from these tables that the colonies appearing on the majority of the plates were very few, with the result that when the duplicate samples really differed by only a colony or two the numerical results per cubic centimeter were quite different, due to the large dilution factor. In the few cases where the germ content of the milk was comparatively high the lower of these dilutions gave fairly satisfactory duplicates. It will also be observed that in a majority of cases the average results per cubic centimeter are progressively higher with the higher dilutions. While these eight sets of observations are too few to establish the fact, they suggest that the observations which indicate the highest germ content are not necessarily the most accurate.

Since these observations indicated that a satisfactory dilution for this work would be somewhat less than 1:100 the testing of the pails was at once begun.

FREEMAN PAIL.

As has been already explained this form of pail was first suggested by Dr. R. G. Freeman. The examples used in these studies were furnished us by Dr. R. A. Pearson before he left Cornell University to take up the duties of Commissioner of Agriculture. This pail (Plate I, fig. 2) was a 12-quart cream can to the top of which Dr. Freeman's hood had been soldered.

On each of eleven days two of four cows were milked into the Freeman pails and two into ordinary 12-inch pails and with the exception of December 2 and 3 these types of pails were alternated with each cow. The results of the bacteriological tests are given in Table II.

Table II. Bacteriological Counts of Milk Drawn into Freeman Pail and into open Pail.

Carey's F, Milked by B.

1908	Freeman Pail				1908	Open Pail			
	dilution—					dilution—			
	1:10	1:20	1:50	1:100		1:10	1:20	1:50	1:100
	Per cc.	*Per cc.*	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*
Nov.					Nov.				
24	820	940	1,000	600	23	1,920	2,020	2,300	1,500
	760	740	600	1,000		1,910	1,780	1,750	2,100
27	770	680	800	700	25	1,500	1,360	1,700	1,500
	560	860	800	800		1,490	1,280	1,350	2,300
30	140	380	300	....	28	580	800	700	
	220	240	250	....		600	580	1,000	
Dec.	210	160	600	....	Dec.	340	460	500	
2	700	300	400	....	1	290	260	150	
3	550	440	1,150	....	4	600	480	700	
	590	440	500	....		570	800	500	
5	390	500	700						
	550	640	650						
Av.	522	527	646	775		980	982	1,115	1,850
Gen. av.	....	617	....	....		....	1,232		

Dotshome Carey, Milked by B.

1908	1:10	1:20	1:50	1:100	1908	1:10	1:20	1:50	1:100
Nov					Nov.				
23	1,510	1,520	1,400	1,500	24	340	540	400	400
	1,520	1,200	850	1,200		430	440	300	500
25	310	340	400	400	27	1,520	1,080	1,350	1,900
	280	180	350	400		1,530	1,300	1,550	1,800
28	110	140	150	....	30	100	60	150	
	120	160	100	....		60	40	50	
Dec.					Dec.				
1	40	40	100	....	2	580	680	600	
	40	40	100	....		420	500	650	
4	130	120	50	....	3	370	460	250	
	80	80	100	....		330	260	400	
					5	270	480	400	
						290	580	500	
Av.	414	382	360	875		520	535	550	1,150
Gen. av.	....	508	....	....		....	688		

TABLE II. BACTERIOLOGICAL COUNT OF MILK DRAWN INTO FREEMAN PAIL AND INTO OPEN PAIL — (*Continued*).

ANNIE G, MILKED BY W.

1908	Freeman Pail				1908	Open Pail			
	DILUTION—					DILUTION—			
	1:10	1:20	1:50	1:100		1:10	1:20	1:50	1:100
	Per cc.	*Per cc.*	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*
Nov.					Nov.				
24	1,520	640	400	400	23	2,670	1,760	2,650	2,500
	1,450	1,160	1,250	600		3,060	2,720	2,950	2,500
27	2,190	2,760	1,900	2,300	25	880	960	1,150	1,000
	2,300	2,760	2,000	2,300		1,800	1,520	2,050	1,700
30	520	480	650	....	28	860	840	800	
	770	1,020	150	....		930	1,160	1,150	
Dec.					Dec.				
2	1,750	1,960	1,700	....	1	1,410	1,740	2,700	
	1,760	1,640	1,900	....		2,320	1,400	1,650	
3	1,050	1,520	1,000	....	4	2,550	3,140	2,830	
	1,150	1,030	1,600	....		2,920	3,260	2,950	
5	1,630	1,980	1,850						
	1,560	1,600	2,100						
Av.	1,471	1,548	1,375	1,400		1,940	1,850	2,115	1,925
Gen. av.	....	1,448	....	....		....	1,957		

HAMMOND, NO. 2, MILKED BY W.

1908	1:10	1:20	1:50	1:100	1908	1:10	1:20	1:50	1:100
Nov.					Nov.				
23	290	400	200	400	24	880	860	1,050	1,700
	1,220	460	300	300		850	940	550	600
25	90	200	300	400	27	590	540	550	700
	190	140	250	200		470	420	650	400
28	360	lost	650	....	30	850	1,140	900	
	440	480	600	....		960	780	1,150	
Dec.					Dec.				
1	210	160	50	....	2	3,200	3,440	3,350	
	220	160	300	....		3,000	2,580	3,250	
4	720	900	900	....	3	5,230	5,620	4,450	
	650	720	650	....		4,830	6,900	4,950	
					5	2,320	2,180	2,450	
						2,410	2,120	2,800	
Av.	439	362	420	325		2,133	2,293	2,175	850
Gen. av.	....	383	....	....		....	1,863		

The number of germs per cubic centimeter in these samples of milk was so small that the dilution 1:100 was soon abandoned

and in the work after November 27, 1908, the dilutions 1:10, 1:20 and 1:50 were used.

The results of these 296 determinations of the germ content are summarized in Table III.

Table III.— Comparative Bacteria Content of Milk Drawn in Freeman and Open Pails.

	Freeman.	Open.
Carey's F.	617	1232
Dotshome Carey	508	688
Annie G.	1448	1957
Hammond No. 2	386	1863
Total	2959	5740
Average	740	1435

Reduction .... 48.4 per ct.

While these results show a marked reduction in germ content with the Freeman pail, the pail was used under strong protest by the milkers and cannot be expected to succeed in general dairies. The items which made it a failure in practice are these: The straight sides make it difficult to hold securely during the milking process; it is 16½ inches high and with our relatively short-legged Jersey cows the milker would occasionally strike his hands unpleasantly against the edge of the hood, and the opening is 6 inches wide, which is too narrow for convenient use with cows where the teats were placed well apart on the udder.

LOY PAIL.

This pail (Plate III, fig. 2) was designed by Mr. Harry Loy and the pails used in this study were made under his supervision.

The comparison of this Loy pail with the 12-inch open pail was made in the same manner as in the preceding comparison with the Freeman pail. The results of the bacteriological examinations are given in Table V.

TABLE V.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO LOY PAIL AND INTO OPEN PAIL.

DOTSHOME CAREY, MILKED BY B.

1908	Loy Pail			1908	Open Pail		
	Dilution—				Dilution—		
	1–10	1–20	1–50		1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Dec. 10	40	100	200	Dec. 11	100	80	350
	30	80	0		40	100	100
12	110	160	0	14	210	200	200
	170	100	250		160	200	350
15	240	260	250	16	1,010	720	1,000
	280	200	350		930	780	1,250
17	310	300	300	18	1,170	1,340	1,450
	260	220	200		1,340	1,140	1,900
19	500	520	700	21	1,700	1,900	1,050
	610	760	900		1,460	1,240	1,500
23	310	500	350	22	940	1,060	1,300
	430	520	400		860	900	1,150
Av.....	274	310	325		827	805	971
Gen. av.	....	303	....		....	868	....

CAREY'S F, MILKED BY B.

11	550	420	250	10	2,020	2,440	2,500
	320	240	350		2,080	1,660	2,250
14	370	420	350	12	1,720	1,900	2,100
	370	380	600		1,700	1,440	1,250
16	1,560	1,540	1,900	15	2,880	2,860	2,900
	1.730	1,800	1,550		1,700	1,640	3,000
18	1,010	1,100	950	17	10,140	12,840	7,800
	830	1,140	1,050		6,960	8,880	10,500
21	730	740	450	19	3,140	3,460	2,500
	540	560	650		2,670	3,340	3,300
22	1,440	1,580	1,350	23	29,000	20,000	29,500
	1,140	1,720	2,150		29,400	29,600	25,000
Av.....	883	970	967		7,784	7,505	7,717
Gen. av.	....	940	....		....	7,669	....

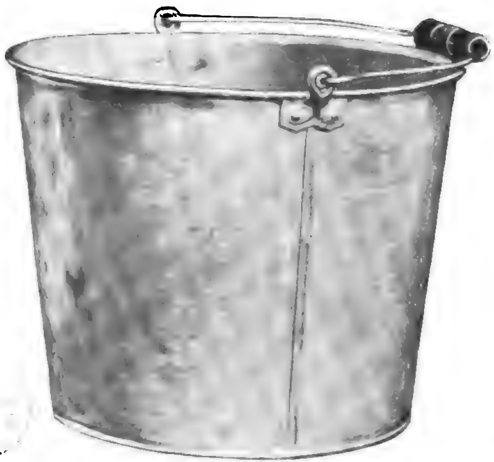

FIG. 1.— OPEN PAIL.

FIG. 2.— FREEMAN PAIL. (Better Form.)

FIG. 3.— FREEMAN PAIL. (Poorer Form.)

PLATE I.— MODERN MILK PAILS.

Fig. 1.—Gurler Pail.

Fig. 2 -- Stadtmueller Pail.

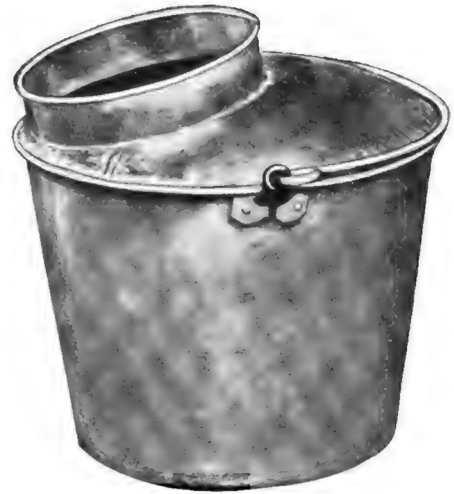

Fig. 3.—Newburgh Pail.

Plate II.—Modern Milk Pails.

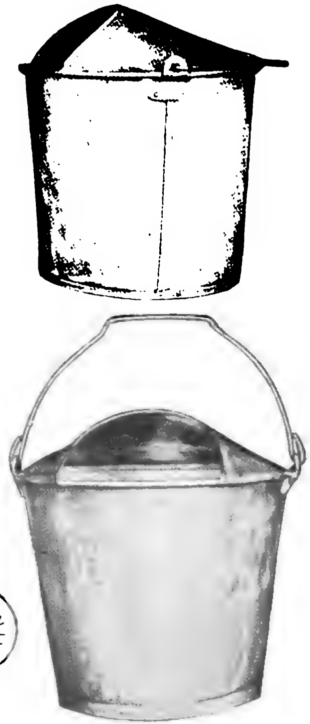

Fig. 1.— Storrs Pail.

Fig. 2.— Loy Pail.

Fig. 3.— Modified Loy Pail.

Plate III.— Modern Milk Pails.

FIG. 1.—ATLANTIC PAIL.

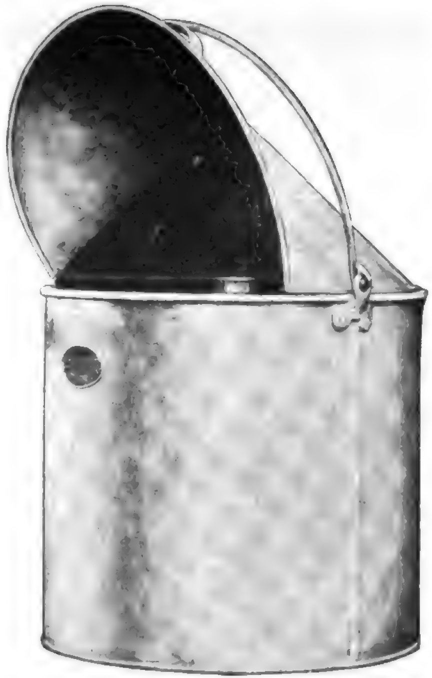

FIG. 2.—CHAMPION PAIL.

FIG. 3.—FRANCISCO PAIL.

PLATE IV.—MODERN MILK PAILS.

TABLE V.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO LOY PAIL AND INTO OPEN PAIL (*Continued*).

ANNIE G, MILKED BY W. & C.

1908	Loy Pail			1908	Open Pail		
	DILUTION—				DILUTION—		
	1-10	1-20	1-50		1-10	1-20	1-50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Dec. 11	3,010	2,940	2,550	Dec. 10	2,750	3,960	3,900
	2,580	3,660	5,050		3,760	3,860	4,050
14	2,260	1,960	950	12	2,340	4,460	3,700
	1,630	1,440	1,550		3,360	3,480	2,000
16	3,470	4,860	3,150	15	2,970	2,760	3,000
	4,400	3,840	3,850		2,560	2,420	1,850
18	2,330	2,900	3,500	17	5,220	6,560	5,100
	1,980	2,680	2,500		4,320	4,800	3,600
21	2,360	4,120	3,100	19	4,330	5,680	6,900
	3,230	4,220	3,050		5,300	3,800	3,650
22	5,520	4,560	4,300	23	6,600	6,120	4,900
	4,720	6,480	3,650		5,400	5,480	4,450
Av.....	3,124	3,638	3,100		4,076	4,448	3,925
Gen. av.	....	3,287	....		....	4,150	....

HAMMOND NO. 2, MILKED BY W. & C.

10	2,540	2,900	3,450	11	16,200	17,000	18,000
	2,510	3,100	2,550		18,800	21,600	17,500
12	7,020	8,520	8,000	14	6,000	4,920	4,600
	5,220	8,040	6,050		4,920	7,440	6,500
15	2,630	2,860	2,350	16	13,320	17,400	25,100
	2,460	2,900	2,100		14,040	17,760	24,300
17	9,960	6,200	10,600	18	32,000	32,000	29,000
	6,060	9,840	13,200		28,600	29,600	45,000
19	8,220	5,640	8,500	21	21,500	31,400	Lost.
	6,060	8,280	9,650		27,100	30,000	26,200
23	16,380	14,280	30,900	22	6,480	5,400	7,550
	12,240	12,120	28,200		7,060	6,880	7,900
Av.....	6,775	7,057	11,046		16,334	18,450	17,600
Gen. av.	....	8,293	....		....	17,461	....

The results of these 288 determinations are summarized in Table VI.

TABLE VI.— COMPARATIVE BACTERIA CONTENT OF MILK DRAWN INTO LOY AND OPEN PAILS.

	Loy.	Open.
Dotshome Carey	303	868
Carey's F.	940	7669
Annie G.	3287	4150
Hammond No. 2	8293	17461
Total	12823	30148
Average	3206	7537
Reduction		56.0 per ct.

This form of milk pail was found so satisfactory both in reduction of germ content and in the process of actual milking that it has been used in our dairy during the intervals between tests of other pails for the past two years. This same form of pail has been used by about forty dairies near Geneva for a year or more with satisfactory results in practically all cases, so that there seems no doubt but that it is a thoroughly practicable milk pail. Those used in these experiments were ordinary 12-quart pails to which had been soldered covers with oval openings 5 x 7¾ inches. These covers were sufficiently convex so that the entire inside of the pail could be easily observed and readily cleaned. Their height was only 12½ inches, so that they could be comfortably used in milking short-legged or heavy-uddered cows.

ATLANTIC PAIL.

This pail (Plate IV, fig. 1) was furnished by the Atlantic Stamping Company. Two of these pails were contrasted at each milking with the two ordinary 12-inch pails which had been used in the preceding studies. The bacteriological results are given in Tables VII.

TABLE VII.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO ATLANTIC PAIL AND INTO OPEN PAIL.

DOTSHOME CAREY, MILKED BY B.

1908–9	Atlantic Pail			1908–9	Open Pail		
	Dilution—				Dilution—		
	1–10	1–20	1–50		1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Dec.				Dec.			
29	200	240	350	28	730	1,240	1,850
	190	280	200		740	700	1,200
31	240	140	100	30	950	1,120	1,000
	230	100	450		870	940	500
Feb.				Feb.			
24	870	960	1,150	23	3,980	3,000	4,400
Mch.							
5	890	1,160	1,450	25	3,240	....	....
	960	1,480	1,050		7,860	6,480	10,700
				Mch.			
9	1,580	2,160	2,450	8	5,840	6,000	6,900
	2,010	2,220	2,700		5,180	6,120	6,550
11	1,540	1,400	1,400	10	5,460	6,360	7,750
	1,620	1,460	2,100		5,040	4,920	8,000
Av.....	939	1,055	1,218		3,627	3,688	4,885
Gen. av.	....	1,071	....		....	4,050	....

CAREY'S F, MILKED BY B.

1908–9	1–10	1–20	1–50	1908–9	1–10	1–20	1–50
Dec.				Dec.			
28	610	600	800	29	4,080	5,980	4,900
	690	440	600		5,460	2,720	7,800
30	1,060	1,400	1,900	31	1,910	1,700	2,000
	1,260	1,200	1,350		1,640	2,220	2,300
Feb.				Feb.			
23	1,910	2,340	2,350	24	1,670	1,560	1,300
				Mch.			
25	5,520	6,360	6,800	5	1,570	1,900	1,400
Mch.					1,630	1,900	....
8	650	530	750	9	5,220	5,400	5,600
	790	940	750		5,880	6,000	7,200
10	1,580	1,800	2,400	11	6,480	5,280	6,200
	2,110	2,060	1,900		6,600	5,360	8,650
Av.....	1,618	1,770	1,960		3,831	3,638	4,735
Gen. av.	....	2,116	....	......		4,068	....

TABLE VII.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO ATLANTIC PAIL AND INTO OPEN PAIL (*Continued*).

ANNIE G, MILKED BY W.

1908–9	Atlantic Pail			1908–9	Open Pail		
	DILUTION—				DILUTION—		
	1–10	1–20	1–50		1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Dec.				Dec.			
28	1,470	1,960	900	29	2,330	3,320	3,350
	1,910	1,080	1,600		2,880	3,360	3,000
30	370	440	500	31	2,960	1,780	1,950
	840	300	500		2,800	2,920	1,400
Feb.				Feb.			
24	10,800	10,920	9,850	23	4,040	4,800	4,500
				25	6,360	4,080	4,700
Mch.				Mch.			
8	2,280	2,640	2,900	5	1,520	2,020	1,750
	2,820	2,640	2,150		2,440	1,540	....
10	3,180	2,760	2,600	9	4,500	4,260	3,050
	3,540	2,560	2,700		3,600	4,280	4,150
11	1,620	1,740	2,000				
	1,310	1,960	2,100				
Av.....	2,740	2,636	2,545		3,343	3,236	3,094
Gen. av.	....	2,640	....		....	3,224	....

HAMMOND NO. 2, MILKED BY W.

1908–9	1–10	1–20	1–50	1908–9	1–10	1–20	1–50
Dec.				Dec.			
29	4,140	4,560	6,000	28	4,830	5,660	6,000
	5,100	4,500	4,750		5,040	7,200	5,100
31	1,490	2,060	1,350	30	3,360	4,860	4,700
	1,940	2,100	1,650		3,180	2,400	3,000
Feb.				Feb.			
23	650	560	900	24	7,920	8,280	9,300
25	2,880	2,620	2,450	Mch.			
Mch.							
5	2,820	2,920	3,400	8	6,300	8.160	9,250
	2,170	2,760	2,700		7,640	6,360	8,650
9	1,660	2,000	1,750	10	3,180	4,360	3,450
	1,700	1,920	2,000		3,920	3,960	3,850
				11	6,480	6,000	7,450
					4,860	6,240	7,900
Av.....	2,455	2.600	2,695		5,156	5,771	6,241
Gen. av.	....	2,583	....		....	5,723	....

The results of these 255 determinations are summarized in Table VIII.

TABLE VIII.— COMPARATIVE BACTERIA CONTENT OF MILK DRAWN INTO ATLANTIC AND OPEN PAILS.

	Atlantic.	Open.
Dotshome Carey	1071	4050
Carey's F.	2116	4068
Annie G.	2640	3224
Hammond No. 2	2583	5723
Total	8410	17065
Average	2102	4266
Reduction	50.7 per ct.	

This pail presents an attractive appearance and the results indicated a satisfactory reduction in germ content. However the pail was 15½ inches high and the opening to receive the milk was 6½ inches wide by 5¼ inches high. The height was such as to interfere with the hands of the milker and the opening was of such a shape as to make milking into it quite difficult. Either of these objections is fatal to the general acceptance of any milk pail and our milkers used these during the tests with the greatest reluctance.

CHAMPION PAIL.

This pail was furnished us by the Champion Milk Cooler Company, and apparently was a tentative effort on their part to produce a distinctive pail. Plate IV, fig. 2.

The results of the bacteriological examinations of the milk obtained in comparison with that obtained in the 12-inch open pails are given in Table IX.

TABLE IX.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO CHAMPION PAIL AND INTO OPEN PAIL.

DOTSHOME CAREY, MILKED BY B.

1909	Champion Pail, dilution— 1–10	1–20	1–50	1909	Open Pail, dilution— 1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Mch. 13	1,120	1,180	1,150	Mch. 12	5,940	5,400	7,200
	960	1,060	1,200		6,640	8,520	8,400
16	910	1,380	1,050	15	3,880	4,460	4,700
	920	940	1,550		4,320	5,520	5,500
18	1,410	1,720	2,000	17	5,280	5,880	7,400
	1,250	1,360	1,150		5,700	6,600	8,150
20	2,080	2,040	1,550	19	4,620	4,160	6,550
	1,820	1,800	1,750		4,140	4,920	4,850
Av.....	1,309	1,435	1,425		5,065	5,683	6,594
Gen. av.	....	1,390	....		....	5,780	....

CAREY'S F, MILKED BY B.

1909	Champion 1–10	1–20	1–50	1909	Open 1–10	1–20	1–50
12	1,450	1,460	1,450	13	2,600	2,280	2,950
	1,150	1,500	1,500		2,350	2,760	2,300
15	850	940	950	16	4,980	5,280	4,800
	710	920	800		7,580	6,000	5,100
17	3,180	3,460	3,000	18	1,470	1,040	1,250
	3,440	3,400	2,700		1,390	1,680	1,850
19	1,430	840	1,300	20	20,000	18,800	29,000
	1,170	1,260	1,250		15,400	16,800	27,000
Av.....	1,673	1,723	1,819		6,966	6,830	9,282
Gen. av.	....	1,673	....		.....	7,693	....

ANNIE G, MILKED BY W. & C.

1909	Champion 1–10	1–20	1–50	1909	Open 1–10	1–20	1–50
13	4,900	4,300	4,050	12	5,020	5,360	7,200
	5,020	4,680	4,650		6,780	8,760	6,550
16	2,470	2,820	2,350	15	6,840	8,040	7,700
	2,460	3,080	2,750		5,400	6,960	8,400
18	3,480	4,160	4,700	17	10,080	11,400	10,500
	4,430	4,000	3,200		9,780	11,760	15,350
20	2,220	2,340	2,350	19	5,100	5,280	5,700
	2,040	2,920	2,100		4,560	5,640	7,200
Av.....	3,377	3,537	3,269		6,695	8,012	8,575
Gen. av.	....	3,394	....		....	7,760	....

Table IX.—Bacteriological Counts of Milk Drawn into Champion Pail and into Open Pail (*Continued*).

Hammond No. 2, Milked by W. & C.

1909	Champion Pail dilution— 1-10	1-20	1-50	1909	Open Pail dilution— 1-10	1-20	1-50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Mch. 12	3,830	4,420	3,400	Mch. 13	4,500	6,480	6,350
	3,600	4,280	3,050		4,380	5,040	5,800
15	4,860	5,280	3,600	16	8,220	9,600	8,350
	4,440	5,400	5,500		7,920	8,520	10,500
17	2,130	2,620	3,300	18	18,960	18,000	22,800
	2,360	2,800	3,450		Lost	23,400	22,700
19	4,800	4,420	5,450	20	10,440	7,800	7,100
	5,160	5,040	6,650		12,900	6,560	6,600
Av.....	3,898	4,283	4,300		8,415	10,675	11,275
Gen. av.	......	4,160	....		....	10,122	....

The results of these 192 determinations are given in Table X.

Table X.—Comparative Bacteria Content of Milk Drawn into Champion and Open Pails.

	Champion.	Open.
Dotshome Carey	1390	5780
Carey's F.	1672	7693
Annie G.	3394	7760
Hammond No. 2.	4160	10122
Total	10616	31355
Average	2654	7839
Reduction ....66.1 per ct.		

Here again the reduction in germ content was encouraging, but as the pail was 17½ inches high it was usable only with difficulty and positive discomfort. From the standpoint of dairy practice it was a failure. This failure was not due to the opening, which

was 9 x 7⅜ inches. The detachable cover made an extra piece to wash and had the pail been placed in the hands of ordinary dairy helpers this cover undoubtedly would have been removed during the milking process. On receiving the comments on our experiences with it the company discontinued its manufacture and put out a much better model. Another pail, devised by Mr. Stephen Francisco, is also made by this company. (Plate IV, fig. 3.)

NEWBURGH PAIL.

This pail (Plate II, fig. 3) is similar to those used in the Brookside dairy at Newburgh, N. Y., and was furnished us through Mr. S. L. Stewart. It is practically identical with the Stadtmüller and the Star pails.

In the preceding comparisons of pails the same four cows had been used in all cases, but in this test it was necessary to substitute Ruth S. and Ruth's F. for Dotshome Carey and Carey's F. The comparison was made in a manner similar to the preceding tests, contrasting two Newburgh pails with two ordinary 12-inch open pails at each milking. The results of the bacteriological tests are given in Table XI.

TABLE XI.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO NEWBURGH PAIL AND INTO OPEN PAIL.

RUTH S, MILKED BY C.

1909	Newburgh Pail, dilution— 1-10	Newburgh Pail, dilution— 1-20	Newburgh Pail, dilution— 1-50	1999	Open Pail, dilution— 1-10	Open Pail, dilution— 1-20	Open Pail, dilution— 1-50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Apr. 28	3,600	3,480	4,450	Apr. 27	11,800	14,600	17,500
	3,980	5,520	3,550		10,300	13,800	21,500
May 3	3,900	3,840	4,500	29	22,400	22,200	27,500
	4,440	4,920	4,400		20,800	24,400	29,500
5	3,600	3,920	3,900	May 4	7,300	6,800	7,500
	4,300	5,000	5,000		6,700	5,800	8,100
				6	41,400	45,200	34,000
					41,800	38,000	31,000
Av.	3,970	4,447	4,300		20,312	21,350	22,075
Gen. av.	....	4,239	....		....	21,246	

Table XI. Bacteriological Counts of Milk Drawn into Newburgh Pail and into Open Pail (*Continued*).

Carey's F, Milked by C.

1909	Newburgh Pail Dilution— 1-10	1-20	1-50	1909	Open Pail Dilution— 1-10	1-20	1-50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Apr. 27	1,200	780	1,400	Apr. 28	3,000	3,720	4,350
	720	760	Lost.		3,800	3,340	3,200
29	2,090	2,060	1,650	May 3	2,080	1,960	1,250
	1,860	2,620	1,940		1,570	1,840	1,450
May 4	2,100	1,920	2,500	5	960	1,440	1,250
	2,300	3,800	2,000		1,000	940	1,200
6	140	160	100				
	170	100	150				
Av.....	1,322	1,525	1,218		2,068	2,207	2,117
Gen. av.	....	1,355	....		....	2,131	

Ruth F, Milked by W.

1909	1-10	1-20	1-50	1909	1-10	1-20	1-50
Apr. 27	1,790	1,840	3,050	Apr. 28	2,140	2,620	3,100
	1,030	1,120	1,650		1,950	2,340	2,150
29	770	1,080	700	May 3	5,100	6,480	6,600
	870	1,020	800		4,400	4,680	3,600
May 4	730	860	950	5	1,700	760	1,150
	870	820	1,050		780	700	950
6	1,200	1,740	2,100				
	1,740	1,520	1,200				
Av.....	1,125	1,250	1,438		2,678	2,930	2,925
Gen. av.	....	1,271	....		....	2,844	

Hammond No. 2, Milked by W.

1909	1-10	1-20	1-50	1909	1-10	1-20	1-50
Apr. 28	2,880	3,820	3,400	Apr. 27	11,300	23,000	17,500
	3,000	3,840	4,250		10,100	13,000	17,000
May 3	5,280	5,600	4,650	29	5,940	6,240	5,400
	6,880	4,160	3,900		5,240	5,400	6,650
5	450	580	500	May 4	5,800	5,000	5,000
	550	640	650		5,200	5,200	5,700
				6	1,520	960	1,850
					1,500	1,320	1,950
Av.....	3,173	3,107	2,892		5,825	7,515	7,632
Gen. av.	....	3,057	....		....	6,991	

The result of these 168 determinations is summarized in Table XII.

TABLE XII.— COMPARATIVE BACTERIA CONTENT OF MILK DRAWN INTO NEWBURGH AND OPEN PAILS.

	Newburgh.	Open.
Ruth S.	4239	21246
Carey's F.	1355	2131
Ruth F.	1271	2844
Hammond No. 2.	3057	6991
Total	9912	33212
Average	2478	8303
Reduction	70.1 per ct.	

When judged either from the standpoint of the bacteriological results or of daily service in the barn this was a satisfactory pail. With a capacity of 12 quarts it was only 10¾ inches high and was provided with a 6¼-inch circular opening near one side of the top. This opening being circular, instead of oval, as with the Loy pail, does not give as much effective milking space for the same exposure and the opening not extending to the rim of the pail offers slightly more difficulty in pouring out the milk and in cleaning the pail.

GURLER PAIL.

This pail (Plate II, fig. 1) was obtained from the Creamery Package Company. Since we had but one of these pails it was contrasted with one open 12-inch pail. The straining cloths were put in place before the pail was steamed and the top of the pail protected by a second cloth until the moment for beginning milking.

The bacteriological results from the milk on 10 days is given in Table XIII.

TABLE XIII.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO GURLER PAIL AND INTO OPEN PAIL.

RUTH F, MILKED BY W.

1909	Gurler Pail, dilution— 1-10	1-20	1-50	1909	Open Pail, dilution— 1-10	1-20	1-50
	Per cc	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
June 2	2,660	2,640	2,950	June 1	2,480	2,480	3,450
	2,510	2,920	3,550		Lost.	2,800	3,500
4	5,220	4,400	4,850	3	5,400	5,280	5,000
	3,200	4,400	5,400		5,400	4,400	4,500
5	8,580	8,280	7,800				
	9,000	7,920	7,800				
7	4,200	4,960	5,400	8	Lost	9,800	9,300
	Lost	4,800	5,600		6,900	8,280	9,600
9	7,380	7,800	12,100	10	*	79,400	51,600
	8,700	11,280	10,200		*	85,600	50,000
11	6,780	5,880	9,550				
	8,040	8,040	7,250				
Av.....	5,523	6,111	6,871		5,045	24,755	17,119
Gen. av.	....	6,168	....		....	15,640	

*Too many to count.

GERTIE F, No. 1, MILKED BY W

1	1,150	1,360	1,100	2	2,330	2,780	2,800
	1,170	1,300	1,100				
3	2,640	2,320	2,500	4	2,430	2,120	2,800
	2,300	2,140	3,000		3,060	3,600	3,100
				5	3,660	2,940	2,750
					3,480	2,520	3,650
8	3,120	3,720	3,450	7	5,760	6,080	11,000
	2,460	3,120	2,500		5,680	5,120	10,000
10	Lost	3,660	3,300	9	1,640	1,300	1,450
	6,420	3,100	3,650		1,320	1,440	1,550
				11	5,100	5,400	6,850
					5,100	5,280	5,550
Av.....	2,408	2,590	2,575		3,597	3,507	
Gen. av.	....	2,524	....		....	3,929	4,648

The results of 114 determinations are given in Table XIV.

TABLE XIV.— COMPARATIVE BACTERIA CONTENT OF MILK DRAWN INTO GURLER AND OPEN PAILS.

	Gurler.	Open.
Ruth F.	6168	15640
Gertie F. No. 1	2524	3929
Total	8692	19569
Average	4346	9785
Reduction	55.6 per ct.	

Directions with this pail call for the use of two thicknesses of cheese cloth to act as a strainer. In practice this is not a satisfactory arrangement. The adjustment of the cloth takes time and if put on after the pail was steamed the cloth would become contaminated in the process. If new cloth is used each time it is an item of expense, and if the cloth is washed and used repeatedly there is strong probability that it will highly contaminate the milk.

The pail was 14¾ inches high which was too tall for best results and had a horse-shoe shaped opening 5¼ x 8 inches. This opening is larger than is necessary. The spout provided for emptying is an added difficulty in cleaning. While the reduction in germ content is fairly satisfactory where a practically sterile pail is used upon a single cow there is little probability that this pail would make a satisfactory showing when used under ordinary conditions and upon a series of cows.

MODIFIED LOY PAIL.

After using the Loy pail in our dairy for some months it became evident that the thin edge of tin around the opening was easily broken and when broken was liable to annoy the milker. Since the form of the opening made it impracticable to turn the edge of the opening over a wire the edge was strengthened by a half-inch strip of tin soldered flush with the inner surface of the cover. This decreased the size of the opening to 5 by 7 inches. Moreover the cover on the original Loy pail had a depression at the point where it joined the edge of the pail, forming a groove. This groove conducted any spattered milk and dust which

mingled with it into the opening of the pail. This was corrected by making the cover flush with the very top of the pail. The projecting support around the opening in the top also assists in preventing the entrance of foreign matter when emptying the milk. (Plate III, fig. 3.)

The results of a ten days' test of the modified Loy pail against a standard 12-inch pail, during June, 1909, is given in Table XV.

TABLE XV.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO MODIFIED LOY PAIL AND INTO OPEN PAIL.

RUTH S., MILKED BY D.

1909	MODIFIED LOY PAIL. DILUTION— 1–10	1–20	1–50	1909	OPEN PAIL DILUTION— 1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
June 1	3,420	4,240	5,700	June 2	4,320	5,400	3,950
	3,680	4,160	4,950		4,500	5,520	4,750
3	1,610	1,880	1,650	4	11,200	10,560	9,900
	1,800	1,580	1,600		9,180	9,000	14,100
				5	35,600	24,400	36,600
					33,600	42,400	22,500
8	1,180	1,440	1,950	7	13,900	12,800	24,900
	970	1,380	1,250		14,200	18,800	37,500
10	2,820	3,120	3,800	9	*	50,400	26,500
	2,040	3,660	3,850		*	53,200	33,000
				11	17,040	21,840	18.000
					15,180	16,440	18,900
Av.....	2,190	2,682	3,093		15,972	22,563	20,800
Gen. av.	....	2,655	....		....	19,778	

*Too many to count.

MILLIE D. MILKED BY D.

2	710	880	600	1	3,000	3,260	4,100
	660	640	500		2,820	2,680	2,880
4	1,600	2,100	1,300	3	1,620	1,640	2,100
	1,130	1,660	1,650		1,620	1,700	2,250
5	4,520	5,040	6,200				
	4,140	5,680	6,300				
7	7,100	9,800	9,000	8	3,420	3,720	2,500
	10,100	9.400	14,500		3,000	3,200	3,150
9	5,820	6,240	7,900	10	3,480	3,720	3,750
	6,720	7,080	8.400		2,940	3,760	3,900
11	4,860	5,580	6,120				
	6,360	5,280	5,700				
Av.....	4,476	4,940	5,680		2,737	2,960	3,078
Gen. av	....	5,032	....		....	2,925	....

The results of these 118 determinations is summarized in Table XVI.

TABLE XVI.—COMPARATIVE BACTERIA CONTENT OF MILK DRAWN INTO MODIFIED LOY AND OPEN PAILS.

	Modified Loy.	Open.
Ruth S.	2655	19778
Millie D.	5032	2925
Total	7687	22703
Average	3843	11351
Reduction	66 per ct.	

The average of these 118 determinations shows a satisfactory reduction of the germ content, but an inspection of the results from Millie D. shows that many more bacteria were found in her milk when drawn into the Modified Loy pail than when milked into the standard open pail. This is an illustration of the contradictory results which are frequently obtained when conclusions are drawn from too small an amount of data.

A year later a second comparison was made between two of the Modified Loy pails and two standard 12-inch pails. In this examination a cubic centimeter of milk in each case was distributed among four plates, and the sum of the colonies found on the four plates was taken as the germ content of the milk. In this way the germs were grown from about three times as much milk as with the previous dilutions. The number of germs found is given in Table XVII.

TABLE XVII.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO MODIFIED LOY PAIL AND INTO OPEN PAIL—SECOND COMPARISON.

COW.	1910 June	Modified Loy Pail					1910 June	12-Inch Open Pail				
		Plate 1	Plate 2	Plate 3	Plate 4	No. per cc.		Plate 1	Plate 2	Plate 3	Plate 4	No. per cc.
Chloe B...	2	72	70	75	95	312	3	144	171	157	167	639
	4	40	29	31	31	131	....	....	....	....	....	....
Millie F...	....	....	....	....	....	....	2	152	201	180	158	691
	3	358	490	528	360	1,728	4	136	80	113	108	437
Millie F B. B.	2	71	50	86	58	265	3	155	156	137	163	611
	4	35	26	16	34	111	....	....	....	....	....	....
Mabel S. F	....	....	....	....	....	....	2	558	678	516	516	2,268
	3	147	210	240	144	741	4	528	492	420	486	1,926
Totals..	....	....	....	....	....	3,288	....	....	....	....	....	6,572
Reduction	....	....	....	....	....	50 %	....	....	....	....	....	....

The resulting reduction is satisfactory when account is taken of the extremely small germ content of the milk in all cases. The relatively high count of Millie F. for June 3 was due to the presence of a practically pure culture of an organism which was abundant in her udder at that time. Stocking[14] has called attention to the fact that the percentage of reduction from the use of a covered pail is increased by using it with dirty cows.

A third comparison of the Modified Loy pail, with the standard 12-inch open pail was made in November, 1910, and the results are given in Table XVIII.

[14] Stocking, W. A., Jr. Comparative study with covered milk pails. Storrs Agr'l Expt. Sta. Bul. 48, p. 90. 1907.

TABLE XVIII.—BACTERIOLOGICAL COUNTS OF MILK DRAWN INTO MODIFIED LOY PAIL AND INTO OPEN PAIL—THIRD COMPARISON.

1910	Modified Loy Pail, Dilution— 1-10	1-20	1-50	1910	Open Pail, Dilution— 1-10	1-20	1-50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
	CAREY OF STATION, MILKED BY B.						
Nov. 11	00	00	150	Nov. 10	100	100	150
	20	20	100		90	40	150
14	160	80	200	12	40	100	200
	150	120	150		60	100	50
16	20	20	000	15	100	60	60
	20	40	50		130	40	50
18	30	00	00	17	40	60	200
	20	00	00		60	40	000
22	20	00	50	21	240	100	50
	00	00	....		50	80	100
Av.	44	28	77.7		91	72	101
Gen. av.	....	50	....		....	88	....
	GERTIE F, NO. 3, MILKED BY B.						
10	10	00	250	11	60	60	150
	10	120	350		90	00	200
12	30	40	00	14	3,190	3,620	4,100
	60	00	00		2,950	4,360	4,500
15	70	00	100	16	80	140	50
	10	140	50		50	60	50
17	10	80	100	18	130	140	100
	10	60	50		50	100	000
21	20	20	50	22	80	20	100
	20	00	50		80	40	
Av.	25	46	100		676	854	1027.7
Gen. av.	....	57	....		....	853	
	CAREY'S FAIRY, MILKED BY C.						
10	90	80	100	11	1,130	900	950
	50	100	100		1,150	980	1,850
12	250	340	300	14	260	100	250
	210	260	500		110	180	150
15	60	60	100	16	520	280	450
	80	40	200		510	800	600
17	60	220	200	18	240	360	450
	90	100	300		130	280	000
21	110	40	250	22	30	20	100
	50	240	100		30	20	150
Av.	105	148	215		411	392	495
Gen. av.	....	156	....		......	433	

Table XVIII.—Bacteriological Counts of Milk Drawn into Modified Loy Pail and into Open Pail—Third Comparison (*Continued*).

Dotshome Carey, Milked by C.

1910	Modified Loy Pail			1910	Open Pail		
	Dilution—				Dilution—		
	1–10	1–20	1–50		1–10	1–20	1–50
	Per cc.	*Per cc.*	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
Nov. 11	200	100	250	Nov. 10	150	160	200
	60	80	150		160	180	200
14	620	500	350	12	500	600	250
	430	480	650		340	460	700
16	120	200	200	15	160	260	400
	80	80	—		310	260	300
18	210	460	500	17	280	240	150
	280	300	—		220	300	250
22	20	20	000	21	50	60	150
	30	40	50		120	80	200
Av.	205	226	268.7		229	260	280
Gen. av.	....	233	....		....	256	

The results of these 236 determinations in 1910 are summarized in Table XIX.

Table XIX.—Comparative Bacteria Content of Milk Drawn into Modified Loy and Open Pails.

	Modified Loy.	Open.
Carey of Station	50	88
Gertie F. No. 3	57	853
Carey's Fairy	156	433
Dotshome Carey	233	256
Total	496	1630
Average	124	408
Reduction	70 per ct.	

Here again the reduction of germ content by the use of the Modified Loy pail is very satisfactory considering the low germ content of the milk obtained in the ordinary way.

In practically all of these determinations the germ content of the milk has been exceptionally low, the product as obtained practically always having a germ content within the limit for certified milk. In considering these results the fact should be borne in mind that this work was planned to shut out practically all of the bacteria except those which were in or on the udder.

CONCLUSIONS.

Pails of the Stadtmüller, Star and Newburgh type, and of the Trueman, Storrs and Loy type are satisfactory both in the ease of milking and in the exclusion of one-half or more of the germs which fall into an ordinary open pail during the milking process.

The most common failing of covered pails is their excessive height. For short-legged or heavy-uddered cows the pails should not be more than 12 inches high over all.

An elliptical opening is preferable to a round one covering the same number of square inches since it is easier to milk into it. While a smaller opening may be used, one 5 x 7 inches, and of the shape seen in the Storrs or Loy pails, will be found practically as convenient as the ordinary open pail.

The cover should be sufficiently convex so that the entire inside of the pail can be seen and easily reached for cleaning. It should be made flush with the very top of the pail so as to avoid a groove which will conduct material from the top of the pail around to the opening and into the milk.

A suitable cover soldered to an ordinary milk pail by a local tinsmith will give satisfaction if the work is well done and all of the seams are carefully filled with solder. Such a cover should add about 50 cents to the cost of the original pail.

REPORT

OF THE

Botanical Department.

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J. G. Grossenbacher, *Associate Botanist.*
G. T. French, *Assistant Botanist.*
F. A. Sirrine, *Special Agent.*

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REPORT OF THE BOTANICAL DEPARTMENT.

POTATO SPRAYING EXPERIMENTS IN 1909.*

F. C. STEWART, G. T. FRENCH, S. M. McMURRAN AND F. A. SIRRINE.

SUMMARY.

This bulletin gives the results of the eighth year's work in the ten-year series of potato spraying experiments begun in 1902. During 1909 the experiments were conducted along the same lines as in previous years. Twenty-six separate experiments are reported.

TEN-YEAR EXPERIMENTS.

At Geneva, six sprayings increased the yield 49.75 bu. per acre and three sprayings increased it 38.67 bu. notwithstanding both early and late blight were wholly absent and there were but few flea beetles. The chief trouble was tip burn. There was no rot. At Riverhead, the gain due to six sprayings was 52.5 bu. per acre and to three sprayings 28.67 bu. The chief enemies were tip burn and flea beetles. There was no late blight and no rot.

FARMERS' BUSINESS EXPERIMENTS.

In twelve farmers' business experiments, including 203 acres, the average gain due to spraying was 24.4 bu. per acre; the average total expense of spraying, $4.15 per acre; and the average net profit, $9.55 per acre. In four of the experiments spraying was unprofitable.

VOLUNTEER EXPERIMENTS.

Twelve volunteer experimenters reported gains averaging 44.4 bu. per acre.

Aside from Colorado potato beetles, which are almost always troublesome, the chief troubles of potato foliage in 1909 were tip burn (caused primarily by dry weather) and flea beetles. Early blight was rare and late blight and rot wholly absent. The experiences of 1909 confirm us in the opinion that it is unwise to neglect spraying in dry seasons.

*A reprint of Bulletin No. 323.

INTRODUCTION.

Does it pay to spray potatoes in New York? Potato growers have been asking this question for fifteen years or more. It is well known that in seasons when blight is destructive spraying will check the blight and considerably increase the yield; but the majority of potato growers have doubted that spraying is profitable on the average. They argue that blight does not appear every year. In some seasons it causes but little if any damage, yet the spraying must be done regularly because it is impossible to foretell the appearance of blight. The result is that in some seasons spraying is profitable while in others it is unprofitable and they doubt that the aggregate gain will pay the expense of spraying for a series of years.

This Station has set out to find an answer to the above question. The investigation was begun in 1902 and is to be continued until 1912. During the ten consecutive years numerous potato spraying experiments will be made each year and at the end of the period the results will be averaged. The experiments are of three kinds: (1) Station ten-year experiments; (2) farmers' business experiments; (3) farmers' volunteer experiments. The ten-year experiments (two each year) are carried out entirely by the Station. The business experiments (13 to 15 each year) are conducted by farmers in coöperation with the Station. The volunteer experiments are carried out entirely by farmers.

Bulletins previously published are:

No. 221. Potato Spraying Experiments in 1902;
No. 241. Potato Spraying Experiments in 1903;
No. 264. Potato Spraying Experiments in 1904;
No. 279. Potato Spraying Experiments in 1905;
No. 290. Potato Spraying Experiments in 1906;
No. 307. Potato Spraying Experiments in 1907;
No. 311. Potato Spraying Experiments in 1908.

SUMMARY OF RESULTS OBTAINED IN TEN-YEAR EXPERIMENTS PRIOR TO 1909.

RESULTS IN 1902.

Table I.— Yield by Series at Geneva in 1902.

Series.	Rows.*	Dates of spraying.	Yield per acre.†	
			Bu.	*lbs.*
I	1, 4, 7 and 13	July 10, 23 and Aug. 12	317	41
II	2, 5, 8 and 14	June 25, July 10, 23, 30, Aug. 12, 26 and Sept. 10	342	36
III	3, 6, 9 and 15	Not sprayed	219	4

* Rows 10, 11 and 12 omitted because of probable error.
† The yields given in Tables I to XIV relate to marketable tubers only.

Increase in yield due to spraying seven times, 123½ *bu. per acre.*

The unsprayed rows died two weeks earlier than the sprayed rows, owing chiefly to a severe attack of late blight. They were also somewhat injured by flea beetles, but there was no early blight. On unsprayed rows the loss from rot was 7½ per ct.; on sprayed rows only an occasional tuber.

Table II.— Yield by Series at Riverhead in 1902.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I	2, 5, 8 and 11	May 26, June 20 and July 12	295	20
II	1, 4, 7 and 10	May 26, June 3, 20 30, July 11, 23 and Aug. 5	312	35
III	3, 6, 9 and 12	Not sprayed	267	40

Increase in yield due to spraying three times, 27⅔ *bu. per acre.*

Increase in yield due to spraying seven times, 45 *bu. per acre.*

In this experiment there were only traces of early blight and no late blight. The larger yield on sprayed rows was due to partial protection against flea beetles which were rather plentiful at times. There was no rot.

RESULTS IN 1903.

TABLE III.— YIELD BY SERIES AT GENEVA IN 1903.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs
I	1, 4, 7, 10 and 13	July 14, 28 and Aug. 26	262	—
II	2, 5, 8, 11 and 14	July 7, 21, Aug. 7, 21 and Sept. 3	292	10
III	3, 6, 9, 12 and 15	Not sprayed	174	20

Increase in yield due to spraying three times, 88 *bu. per acre.*
Increase in yield due to spraying five times, 118 *bu. per acre.*

Three sprayings prolonged the life of the plants 11 days; five sprayings, 18 days. There was no early blight and the injury from flea beetles was only slight. Late blight was again the chief enemy. The loss from rot was even less than in 1902.

TABLE IV.— YIELD BY SERIES AT RIVERHEAD IN 1903

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I	1, 4, 7 and 10	June 5, July 22 and Aug. 7	246	45
II	2, 5, 8 and 11	June 5, 24, July 7, 22 and Aug. 7.	263	10
III	3, 6, 9 and 12	Not sprayed	207	10

Increase in yield due to spraying three times, 39½ *bu. per acre.*
Increase in yield due to spraying five times, 56 *bu. per acre.*

The sprayed rows outlived those unsprayed by several days. Late blight and flea beetles were the chief enemies. Early blight, also, caused slight damage. On the unsprayed rows the loss from rot was 2 per ct.; on those sprayed, practically nothing.

RESULTS IN 1904.

Table V.— Yield by Series at Geneva in 1904.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I..........	1, 4, 7, 10 and 13..	July 13, 27 and Aug. 15............	344	30
II..........	2, 5, 8, 11 and 14..	July 8, 22, Aug. 1, 15 and 29........	386	40
III..........	3, 6, 9, 12 and 15..	Not sprayed......................	153	25

Increase in yield due to spraying three times, 191 *bu. per acre.*
Increase in yield due to spraying five times, 233 *bu. per acre.*

Spraying prolonged the life of the plants 25 days. Late blight was the only trouble. On both sprayed and unsprayed rows there was a little rot at digging time. In storage, the sprayed potatoes rotted most. Spraying materially improved the cooking qualities.

Table VI.— Yield by Series at Riverhead in 1904.

Series.	Rows.	Dates of spraying.	Yield per acre,	
			Bu.	*lbs.*
I..........	1, 4, 7 and 10.....	June 14, July 21 and Aug. 9........	257	58
II..........	2, 5, 8 and 11.....	June 14, 27, July 11, 26, Aug. 9 and 22	297	45
III..........	3, 6, 9 and 12.....	Not sprayed......................	201	25

Increase in yield due to spraying three times, 56½ *bu. per acre.*
Increase in yield due to spraying six times, 96⅓ *bu. per acre.*

The larger yield on sprayed rows was due chiefly to partial protection against flea beetles which are unusually abundant. Both early and late blight also present. The loss from rot was 3 per ct. on Series I, 1 per ct. on Series II, and 6 per ct. on Series III.

RESULTS IN 1905.

TABLE VII.— YIELD BY SERIES AT GENEVA IN 1905.

Series.	Rows.*	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I	4, 7, 10 and 13	July 3, August 7 and 25	228	45
II	5, 8, 11 and 14	June 29, July 13, 27, Aug. 12 and 24	241	15
III	6, 9, 12 and 15	Not sprayed	121	52

* Rows 1, 2 and 3 omitted because of error.

Increase in yield due to spraying three times, 107 *bu. per acre.*
Increase in yield due to spraying five times, 119½ *bu. per acre.*

From the combined attack of flea beetles, tip-burn and late blight the unsprayed rows died fully two weeks earlier than the sprayed ones. Spraying reduced the loss from rot at the rate of 41 bushels per acre. There was no subsequent rot in storage.

TABLE VIII.— YIELD BY SERIES AT RIVERHEAD IN 1905.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I	1, 4, 7, 10 and 13	June 14, July 18 and Aug. 11	253	—
II	2, 5, 8, 11 and 14	June 14, 30, July 14, 28 and Aug. 11	303	41
III	3, 6, 9, 12 and 15	Not sprayed	221	38

Increase in yield due to spraying three times, 31⅓ *bu. per acre.*
Increase in yield due to spraying five times, 82 *bu. per acre.*

Late blight caused no injury in this experiment and there was not even a trace of rot. Flea beetles and early blight were the enemies fought.

RESULTS IN 1906.

TABLE IX.— YIELD BY SERIES AT GENEVA IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I..........	1, 4, 7, 10 and 13..	July 9, August 10 and 30...........	227	25
II..........	2, 5, 8, 11 and 14..	July 6, 20, Aug. 6, 20 and 21........	258	40
III..........	3, 6, 9, 12 and 15..	Not sprayed........................	195	40

Increase in yield due to spraying three times, 31¾ bu. per acre.
Increase in yield due to spraying five times, 63 bu. per acre.

Late blight, early blight, flea beetles and tip burn were all factors in this experiment, but none of them caused much damage. Spraying controlled blight and flea beetles completely and tip burn partially. The loss from rot was negligible, only four rotten tubers being found in the entire experiment.

TABLE X.— YIELD BY SERIES AT RIVERHEAD IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I..........	1, 4, 7, 10 and 13..	June 12, July 18 and August 6......	172	—
II..........	2, 5, 8, 11 and 14..	June 12, 25, July 10, 25 and Aug. 6..	203	45
III..........	3, 6, 9, 12 and 15..	Not sprayed.......................	150	30

Increase in yield due to spraying three times, 21½ bu. per acre.
Increase in yield due to spraying five times, 53¼ bu. per acre.

In the experiment at Riverhead the principal enemies were late blight and flea beetles, there being a moderate attack of both. Early blight was not sufficiently abundant to cause material injury. There was no loss from rot.

RESULTS IN 1907.

TABLE XI.— YIELD BY SERIES AT GENEVA IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I	1, 4, 7, 10 and 13	July 15, Aug. 9 and 24	220	15
II	2, 5, 8, 11 and 14	July 15, 24, Aug. 9, 24 and Sept. 17	249	50
III	3, 6, 9, 12 and 15	Not sprayed	176	10

Increase in yield due to spraying three times, 44 bu. per acre.
Increase in yield due to spraying five times, 73⅔ bu. per acre.

Late blight and rot were wholly absent and early blight appeared only in traces. There was some tip burn and a light attack of flea beetles. Considering the seemingly small amount of damage done by blight and insects it is remarkable that spraying should have increased the yield so much.

TABLE XII.— YIELD BY SERIES AT RIVERHEAD IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I	1, 4, 7, 10 and 13	June 19, July 25 and Aug. 15	186	45
II	2, 5, 8, 11 and 14	June 19, July 2, 17, 31, Aug. 15 and 29	200	5
III	3, 6, 9, 12 and 15	Not sprayed	168	50

Increase in yield due to spraying three times, 18 bu. per acre.
Increase in yield due to spraying six times, 31¼ bu. per acre.

There was some early blight, but no late blight. Flea beetles were plentiful and caused much damage. The larger yield of the sprayed rows is to be attributed to their partial protection against flea beetles and early blight.

RESULTS IN 1908.

TABLE XIII.— YIELD BY SERIES AT GENEVA IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre. Bu.	lbs.
I	1, 4, 7, 10 and 13	July 3, 17 and Aug. 3	155	40
II	2, 5, 8, 11 and 14	July 3, 17, Aug. 3, 18, Sept. 1 and 16	165	10
III	3, 6, 9, 12 and 15	Not sprayed	126	10

Increase in yield due to spraying three times, 29½ bu. per acre.
Increase in yield due to spraying six times, 39 bu. per acre.

There was no early blight, no late blight and no rot. Flea beetles caused slight damage to the unsprayed rows, most of which occurred after September 1. The chief trouble was tip burn, which was quite severe. The sprayed rows of Series II outlived the unsprayed rows of Series III by about five days owing, apparently, to the smaller amount of tip burn and flea beetle injury on the sprayed rows.

TABLE XIV.— YIELD BY SERIES AT RIVERHEAD IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre. Bu.	lbs.
I	1, 4, 7, 10 and 13	June 11, July 9 and Aug. 4	147	35
II	2, 5, 8, 11 and 14	June 11 25, July 9, 24 and Aug. 4	152	10
III	3, 6, 9, 12 and 15	Not sprayed	136	50

Increase in yield due to spraying three times, 10¾ bu. per acre.
Increase in yield due to spraying five times, 15⅓ bu. per acre.

In this experiment there was some early blight and a moderate attack of flea beetles, but no late blight and no rot. During July considerable damage was done by aphids which were not checked by the spraying.

DETAILS OF THE TEN-YEAR EXPERIMENTS IN 1909.

AT GENEVA.

In 1909, the experiment was carried out in practically the same manner as in previous years. As usual, there were 15 rows, 290.4 feet long by 3 feet wide.[1] Planting was done by hand May 26. The variety was Rural New Yorker No. 2. Each row received ten pounds of chemical fertilizer applied by hand as uniformly as possible in the open furrow at planting time. The plat of land used was the same as that used for the experiment in 1908. The soil was heavy clay loam. The potatoes came up well so that there were but few missing hills.

The five rows constituting Series I were sprayed three times with bordeaux — July 9, 23 and August 11.

The five rows constituting Series II were sprayed six times with bordeaux — July 9, 23, August 11, 27, September 10 and 24.

The five rows constituting Series III (check) were not sprayed at all with bordeaux.

Bugs were controlled by spraying the entire field twice (July 3 and 20) with paris green in lime water (1 lb. to 50 gals.) Thus all three series received the same treatment as regards poison for bugs. However, it should be stated that at the time of making the second application of paris green (July 20) bugs were numerous and had slightly injured some of the plants. This injury was somewhat greater on Series III (check) than on Series I and II sprayed with bordeaux. Bugs dislike bordeaux mixture. It has been our custom, in these experiments, to apply poison for bugs simultaneously with the first two applications of bordeaux, but this year it was not convenient to do so.

In each application the work was done very thoroughly with a knapsack sprayer, using 125 to 250 gallons of bordeaux per acre. The bordeaux mixture used contained six pounds of copper sulphate to each fifty gallons, and lime somewhat in excess of the amount required to satisfy the potassium ferro-cyanide test.

[1] Besides the fifteen rows in the experiment proper there were, as in all previous experiments, two other rows which served the purpose of outside rows.

Both early blight and late blight were wholly absent. Some injury from flea beetles was noticeable throughout the season. After about September 1 there was, also, considerable tip burn owing to the drought prevailing at that time. But as late as September 24 the difference between sprayed and unsprayed rows was not marked. The difference between Series I and II was very slight indeed. The sprayed rows held most of their foliage until killed by frost on October 14. Even at this date the difference in the foliage indicated that there would be only slight difference in the yield of the three series.

The potatoes were dug by hand and sorted and weighed in the usual manner. No rotten tubers were found. The yield by rows is shown in the following table:

TABLE XV.— YIELDS IN THE EXPERIMENT AT GENEVA IN 1909.

Row.	TREATMENT.	Yield per Row.*		Yield per Acre.			
		Marketable.	Culls.	Marketable.		Culls.	
		Lbs.	Lbs.	Bu.	lbs.	Bu.	lbs.
1	Sprayed three times	191	3	159	10	2	30
2	Sprayed six times	190	3½	158	20	2	55
3	Unsprayed	136	6	113	20	5	—
4	Sprayed three times	170	6	141	40	5	—
5	Sprayed six times	203	5	169	10	4	10
6	Unsprayed	143	6	119	10	5	—
7	Sprayed three times	204	6	170	—	5	—
8	Sprayed six times	204½	4	170	25	3	20
9	Unsprayed	150	7	125	—	5	50
10	Sprayed three times	205	5½	170	50	4	35
11	Sprayed six times	213	5	177	30	4	10
12	Unsprayed	153½	5	127	55	4	10
13	Sprayed three times	204	5½	170	—	4	35
14	Sprayed six times	230	5	191	40	4	10
15	Unsprayed	159½	4	132	55	3	20

*Rows 290.4 feet long by 3 feet wide, making the area of each row exactly one-fiftieth acre.

Yield by series.— The five rows sprayed three times constitute Series I and the average yield of these rows makes the yield for Series I. The yields given for Series II and III have been computed in the same way. The yield by series is shown in the following table:

TABLE XVI.— YIELD BY SERIES AT GENEVA IN 1909.

Series.	Rows.	Dates of spraying.	Yield per acre.*	
			Bu.	*lbs.*
I..........	1, 4, 7, 10 and 13..	July 9, 23 and Aug. 11..............	162	20
II..........	2, 5, 8, 11 and 14..	July 9, 23, Aug. 11, 27, Sept. 10 and 24	173	25
III..........	3, 6, 9, 12 and 15..	Not sprayed.......................	123	40

* Marketable tubers only.

Increase in yield due to spraying three times, 38¾ bu. per acre.
Increase in yield due to spraying six times 49¾ bu. per acre.

AT RIVERHEAD.

The experiment at Riverhead was carried out in practically the same manner as the one at Geneva. There were fifteen rows 290.4 feet long by three feet wide. The seed tubers, variety Carman No. 1, were planted April 21 with a Robbins potato planter which, at the same time applied chemical fertilizer at the rate of 1,000 pounds per acre. The soil was sandy loam and the previous crop timothy hay. When the plants came up there were few missing hills.

The five rows of Series I were sprayed three times (June 11, July 16 and 31), with bordeaux and paris green. They were also treated twice (June 25 and July 7) with paris green and lime water.

The five rows of Series II were sprayed six times with bor deaux and paris green, the dates being June 11, 25, July 9, 24, August 6 and 21.

The five rows of Series III (check) were not sprayed at all with bordeaux, but were treated three times (June 18, 25 and July 7) with paris green in lime water to control bugs.

All of the applications were made with a knapsack sprayer, and the work was done very thoroughly. The bordeaux was prepared in the same manner as in the Geneva experiment. In the use of paris green there were some variations, but it was so man-

aged that there was not at any time any material injury done by bugs.

After July 7 there was a little early blight, but no late blight at any time. Some flea beetles were present, as usual, during May and June, but caused practically no damage. The new brood appeared about July 15 and thereafter beetles were a factor in the experiment though less numerous and less destructive than usual. After about the middle of July the plants suffered severely from drought, but they did not present the usual symptoms. Instead of showing tip burn the leaves became overgrown with a dark-colored mold consisting chiefly of *Cladosporium herbarum* (?).

From July 15th until the plants were all dead the sprayed rows were noticeably superior to the unsprayed ones. Strange to say, this difference was more marked during the latter part of July than on August 21. On the latter date some plants in Series III were still alive, apparently having made a second growth.

The potatoes were dug, sorted and weighed on October 19. No rotten tubers were found. The yields were as follows:

Table XVII.— Yields in the Experiment at Riverhead in 1909.

Row.	Treatment.	Yield per Row.* Marketable.	Yield per Row.* Culls.	Yield per Acre. Marketable.		Yield per Acre. Culls.	
		Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
1	Sprayed three times	179	8	149	10	6	40
2	Sprayed six times	177	6	147	30	5	—
3	Unsprayed	127	8½	105	50	7	5
4	Sprayed three times	135	8	112	30	6	40
5	Sprayed six times	178	9	148	20	7	30
6	Unsprayed	141	8	117	30	6	40
7	Sprayed three times	157	7	130	50	5	50
8	Sprayed six times	189	4	157	30	3	20
9	Unsprayed	122	7	101	40	5	50
10	Sprayed three times	174	5	145	—	4	10
11	Sprayed six times	214	5	178	20	4	10
12	Unsprayed	121	8	100	50	6	40
13	Sprayed three times	174	4	145	—	3	20
14	Sprayed six times	204	7	170	—	5	50
15	Unsprayed	136	9	113	20	7	30

*Rows 290.4 feet long by 3 feet wide, making the area of each row exactly one-fiftieth acre.

TABLE XVIII.— YIELD BY SERIES AT RIVERHEAD IN 1909.

SERIES.	Rows.	Dates of spraying.	Yield per acre.*	
			Bu.	lbs.
I.	1, 4, 7, 10 and 13	June 11, July 16 and 31	136	30
II.	2, 5, 8, 11 and 14	June 11, 25, July 9, 24, Aug. 6 and 21	160	20
III.	3, 6, 9, 12 and 15	Not sprayed	107	50

* Marketable tubers only. Owing to their small average size it was deemed advisable to make two grades of the marketable tubers; "firsts" which sold for 80 cents per bushel and "seconds" which sold for 40 cents. The increase in yield due to spraying was chiefly in the grade of "firsts," the yields being as follows:

Rows sprayed three times, 75⅓ bu. "firsts" and 61⅙ bu. "seconds;" rows sprayed six times, 100 bu. "firsts" and 60⅓ bu. "seconds;" unsprayed rows, 50 bu. "firsts" and 57⅚ bu. "seconds."

Increase in yield due to spraying three times, 28⅔ bu. per acre.

Increase in yield due to spraying six times, 52½ bu. per acre.

For the first time in the eight years during which these experiments have been running the gain from six sprayings was slightly greater at Riverhead than at Geneva, the amount of the difference being 2¾ bu. per acre. However, the gain from three sprayings was ten bushels *less* at Riverhead than at Geneva. Usually, the gains at Geneva have been much larger than those at Riverhead. This is shown in the next table.

SUMMARY OF RESULTS OBTAINED IN THE TEN-YEAR EXPERIMENTS, 1902–1909.

The following table shows the results obtained in the ten-year experiments during the first eight years:

TABLE XIX.— SUMMARY OF THE TEN-YEAR EXPERIMENTS FOR EIGHT YEARS.

YEAR.	AT GENEVA.		AT RIVERHEAD.	
	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.
	Bu.	Bu.	Bu.	Bu.
1902	123½	98½	45	27¾
1903	118	88	56	39½
1904	233	191	96	56¼
1905	119	107	82	31½
1906	63	32	53	21½
1907	73¾	44	31	18
1908	39	29½	15½	10¾
1909	49¾	38⅔	52½	28⅔
Average	102 +	78 +	54—	29 +

FARMERS' BUSINESS EXPERIMENTS.

During the season of 1909 twelve farmers in different parts of the State conducted business experiments for the Station. The object of these experiments is to determine the actual profit in spraying potatoes under farm conditions. The methods employed were essentially the same as in previous years. An accurate record was kept of all of the expense of spraying, including labor, chemicals and wear of machinery. In each experiment a strip of three to six rows was left unsprayed for comparison.

In order to bring the account of the experiments within the required space limit it has been necessary to omit many interesting details.

"Spraying" as used in this bulletin, means the application of bordeaux mixture exclusively. The application of paris green or arsenite of soda in lime water is not called spraying.

Whenever "arsenite of soda" is mentioned it should be understood to mean the stock solution prepared by the Kedzie formula — one pound white arsenic, four pounds sal soda and one gallon of water boiled together twenty minutes.

By "test rows" is meant the rows used in determining the amount of the increase in yield due to spraying. These are, usually, the middle unsprayed row and the second sprayed row on either side.

The yields given are for marketable tubers only.

The price used in computing the value of the increased yield is, in every case, the market price for potatoes in the locality where the experiment was made on the date on which the test rows were dug.

THE BATAVIA EXPERIMENT.

Conducted by G. A. Prole, Batavia, N. Y. Fifteen acres of potatoes were sprayed six times with a two-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The dates of spraying were July 10, 17, 30, August 10, 20 and 27. Water was obtained from a well about forty rods from the field. The pumping was done by a windmill. Poison (arsenite of soda) was used with the bordeaux in the first spraying at the rate of three quarts of the stock solution to fifty gallons. The check consisted of a strip of three unsprayed rows 1,256 feet long, thirty-two inches apart. These were treated once (July 10) with paris green to control bugs. Sprayed and unsprayed rows were practically indistinguishable until within a few days of the close of growth, when the unsprayed rows appeared slightly inferior. There was no early blight, no late blight and no rot. The chief troubles were flea beetles and tip burn, neither of which caused much damage.

The expense account contained the following items:

402	lbs. copper sulphate @ 5c	$20 10
3½	bus. lime @ 25c	88
28	lbs. sal soda @ 2½c	70
7	lbs. white arsenic @ 12c	84
94	hrs. labor for man @ 20c	18 80
94	hrs. labor for horse @ 10c	9 40
	Use of sprayer (hired)	5 00
	Total	$55 72

The test rows (Sir Walter Raleigh) yielded as follows: Two sprayed rows.[2] 1,441 lbs.= 156.1 bu. per acre.

Middle unsprayed row, 728 lbs.= 157.7 bu. per acre.

LOSS, 1.6 bu. per acre.

To the expense of spraying, which was $3.71 per acre, must be added the loss of 1.6 bu. of potatoes, worth eighty cents, which makes *the total loss* $4.51 *per acre.*

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[2] One row on east side of check, 696 lbs.; the other on west side, 745 lbs.

THE VICTOR EXPERIMENT.

Conducted by William C. Green, Victor, N. Y. Twelve acres of potatoes (variety Carman No. 3), were sprayed twice (July 17 and August 6) with bordeaux mixture, formula 5-5-50. The sprayer used was a one-horse, home-made, four-row sprayer, carrying one nozzle per row. The potato field was only about ten rods from the water supply. A windmill did the pumping. Four rows 948 feet long by 34 inches wide were left unsprayed for a check. Owing to the absence of bugs it was unnecessary to use any poison, either on the sprayed or the unsprayed rows. While the field as a whole was sprayed only twice, the four rows next the check, on the east side, were double-sprayed four times. One of these rows was used to represent the sprayed rows at digging time. In spite of their thorough spraying the sprayed rows appeared no better than the unsprayed ones. This is not strange, because there was no blight, only a few flea beetles and a little tip burn.

The items of expense were as follows:

120 lbs. copper sulphate @ 6c	$7 20
120 lbs. lime @ ½c	60
20 hrs. labor for man @ 20c	4 00
20 hrs. labor for horse @ 10c	2 00
Allowance for wear of sprayer	5 00
Total	$18 80

Expense of spraying one acre once, 78⅓ cents.

Expense of spraying one acre eight times, $6.27.

The yields were as follows:[3]

One row sprayed eight times, 776 lbs.= 209.6 bu. per acre.

One unsprayed row, 782 lbs.= 211.2 bu. per acre.

Loss, 1.6 bu. per acre.

There being a *decrease* instead of an increase in yield the expense of spraying, $1.57 per acre, was all lost. To this must be added 64 cents, the value of 1.6 bu. potatoes, which makes the actual total loss $2.21 per acre. Had the whole field been double-sprayed four times like the test rows the total loss would have been $6.91 per acre.

[3] There were so few small tubers that sorting was unnecessary.

THE ELMIRA EXPERIMENT.

Conducted by John Strouse, Elmira, N. Y. About twenty-two acres of potatoes (in two lots) were sprayed twice with bordeaux by means of a two-horse, six-row "Perfection" sprayer, carrying one nozzle per row. Part of the water required was obtained from a creek and the remainder from a well nearby. In both lots three-row checks were left. In both sprayings arsenate of lead was used with the bordeaux at the rate of four pounds to fifty gallons. This seems to have been unnecessary. It was the intention to use arsenate of lead on the check rows, also, as soon as bugs attacked them, but no bugs appeared and so no poison was applied. There was some tip burn and a few flea beetles, but no blight. Sprayed and unsprayed rows appeared equally good throughout the season.

The expense account contained the following items:

176 lbs. copper sulphate @ 6c	$10 56
4 sacks hydrated lime @ 30c	1 20
84 lbs. arsenate of lead @ 14c	11 76
24 hrs. labor for man @ 12½c	3 00
21 hrs. labor for team @ 30c	6 30
Wear on sprayer	3 50
Total	$36 32

Average expense of two sprayings, $1.65 per acre.

The test rows (Carman No. 3) yielded as follows:[4]

Lot No. 1.—Rows 516 feet long by 3 feet wide.

One sprayed row, 347 lbs.= 162.7 bu. per acre.

One unsprayed row, 328 lbs.= 153.8 bu. per acre.

Gain, 8.9 bu. per acre.

Lot No. 2.—Rows 488 feet long by 3 feet wide.

Two sprayed rows,[5] 586 lbs.= 145.3 bu. per acre.

One unsprayed row, 297 lbs.= 147.3 bu. per acre.

Loss, 2 bu. per acre.

The average gain in the two tests being 6.9 bu. per acre, worth (at 50 cents per bu.) $3.45, and the average expense of spraying being $1.65 per acre, there was *a net profit of* $1.80 *per acre.*

[4] Potatoes not sorted.
[5] One south of check, 273 lbs.; the other north of check, 313 lbs.

THE STERLING STATION EXPERIMENT.

Conducted by A. E. Curtis, Sterling Station, N. Y. One field of 6.33 acres was sprayed six times; another of 8.14 acres, seven times. The sprayer was a one-horse, four-row, home-made affair carrying four nozzles per row, A four-row check was left in each field. The bordeaux used was of the 6-10-45 formula. Paris green for bugs was applied once on the sprayed rows, also once on the check rows. Both kinds of blight were absent. There was some tip burn, but the chief trouble was flea beetles which were quite plentiful. Toward the close of the season the difference in appearance between sprayed and unsprayed rows became quite noticeable in both fields.

The expense of spraying 6.33 acres six times and 8.14 acres seven times was as follows:

555	lbs. copper sulphate @ 6½c	$36 08
3½	bbls. lime @ $1.25	4 38
30	lbs. paris green @ 25c	7 50
13	days labor for man @ $1.50	19 50
13	days labor for horse @ $1	13 00
	Wear of sprayer	5 00
	Total	$85 46

The test rows (Carman No. 3) showed the following yields:

Field No. 1.— Sprayed six times. Rows 442 x 3 feet.

One sprayed row, 246 lbs.= 134.7 bu. per acre.

One unsprayed row, 214 lbs.= 117.2 bu. per acre.

Gain, 17.5 bu. per acre.

Field No. 2.— Sprayed seven times. Rows 546 x 3 feet.

One sprayed row, 340 lbs.= 150.7 bu. per acre.

One unsprayed row, 245 lbs.= 108.6 bu. per acre.

Gain, 42.1 bu. per acre.

In the two tests the average gain per acre was 29.8 bu. worth, at 45 cents per bu., $13.41. In one field the expense of spraying was $5.40 per acre and in the other $6.30, the average being $5.85 per acre. Subtracting this sum from $13.41 leaves *a net profit of $7.56 per acre.*

THE EAST SYRACUSE EXPERIMENT.

Conducted by M. W. Garrett, East Syracuse, N. Y. Four and one-half acres of potatoes, variety Norcross, were sprayed three times — July 9, 16 and 26. The sprayer used was a one-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The bordeaux was of the 6-6-50 formula made with water pumped by hand from a well about twenty rods from the field. Paris green, at the rate of one pound to fifty gallons, was used with the bordeaux in all three sprayings. The four check rows, also, were treated with paris green three times — July 9, 18 and 30. Both kinds of blight and flea beetles were absent. Throughout the season the foliage on the sprayed rows was slightly inferior to that on the unsprayed rows. Apparently the plants were slightly injured by spraying. This strange condition was observed also in Mr. Garrett's 1908 experiment.[6] Mr. Garrett now suspects that the trouble, in both seasons, was due to the use of a poor grade of hydrated lime. In the future he will use lump lime.

The expense account contained the following items:

100 lbs. copper sulphate @ 6c	$6 00
100 lbs. hydrated lime	45
10 lbs. paris green @ 25c	2 50
10 hrs. labor for man @ 25c	2 50
10 hrs. labor for horse @ 15c	1 50
Wear of sprayer	5 00
Total	$17 95

Average expense of three sprayings, $3.99 per acre.

The test rows (425 x 3 ft.) yielded as follows:

Two sprayed rows,[7] 449.5 lbs.= 130.9 bu. per acre.

One unsprayed row, 235.25 lbs.= 136.9 bu. per acre.

Loss, 6 bu. per acre.

At sixty cents per bu. six bu. of potatoes have a value of $3.60. To this must be added the expense of spraying, $3.99 per acre, which makes the *total loss* $7.59 *per acre.*

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[6] See Bul. 311 of this Station, page 22.

[7] One row north of check, 202.5 lbs.; the other south of check, 247 lbs.

THE OGDENSBURG EXPERIMENT.

Conducted at Ogdensburg, N. Y., by Andrew Tuck who sprayed 5.7 acres of potatoes seven times on the following dates: July 19, 26, August 2, 10, 21, 30 and September 9. The sprayer used was a one-horse, four-row "Aspinwall" sprayer carrying one nozzle per row. The bordeaux was of the 5–5–50 formula made with water pumped by hand from a well about 96 rods from the field. Paris green (2½ lbs. to 50 gallons) was used with the bordeaux in four sprayings. The three check rows, also, were treated four times with paris green. When this experiment was examined by one of the writers on August 31 there appeared to be but little if any difference between sprayed and unsprayed rows. There was some tip burn and some injury by flea beetles. Later, Mr. Tuck reports that blight was absent and that there was no contrast between sprayed and unsprayed rows. No rotten tubers were found at digging time.

The expense account contained the following items:

140 lbs. copper sulphate @ 7c	$9 80
140 lbs. lime	1 75
40 lbs. paris green @ 25c	10 00
45 hrs. labor for man @ 15c	6 75
45 hrs. labor for horse @ 5c	2 25
Wear of sprayer	1 00
Total	$31 55

The test rows were of the variety Rural New Yorker No. 2. They were 936 ft. long by 3 ft. wide. The yields were as follows:

One sprayed row, 626 lbs.=161.8 bu. per acre.

Middle unsprayed row, 556 lbs.=143.7 bu. per acre.

Gain, 18.1 bu. per acre.

Potatoes being worth 50 cents per bushel at time of digging the test rows (October 5), the market value of the gain was $9.05. After subtracting the expense of spraying, $5.53 per acre, there remains *a net profit of* $3.52 *per acre.*

THE CHATEAUGAY EXPERIMENT.

Conducted by O. Smith & Son, Chateaugay, N. Y. Twelve acres were sprayed three times with a one-horse, four-row "Iron Age" sprayer carrying one nozzle per row. Bordeaux of the 6–6–50 formula was used, the necessary water being pumped by hand from a stream at one side of the field. Arsenite of soda (2½ to 3 qts. in 50 gals.) was used with the bordeaux in two sprayings. A few rows on each side of the checks received a fourth spraying on September 11. The checks consisted of two unsprayed strips of three rows each. On these rows three applications of paris green kept bugs completely under control. On September 1 there was very little difference between sprayed and unsprayed rows. In fact there was no marked contrast at any time during the season. There were traces of early blight, some flea beetle injury and a severe attack of tip burn, but no late blight. The variety was Sir Walter Raleigh.

The expense account contained the following items:

222	lbs. copper sulphate @ 7¾c	$17 20
1½	bbls. lime @ $1.10	1 65
120	lbs. sal soda @ 1c	1 20
30	lbs. white arsenic @ 10c	3 00
14¾	hrs. labor for man @ 15c	2 21
12¾	hrs. labor for horse @ 15c	1 91
	Wear on sprayer	10 00
	Total	$37 17

The test rows gave the following yields:

East test.— Rows 609 ft. long by 3 ft. wide.

Two sprayed rows,[8] 1,295 lbs.=257.3 bu. per acre.

Middle unsprayed row, 467 lbs.=185.6 bu. per acre.

Gain, 71.7 bu. per acre.

West test.— Rows 542 ft. long by 3 ft. wide.

Two sprayed rows,[9] 1,469 lbs.= 327.8 bu. per acre.

Middle unsprayed row, 577 lbs.= 257.3 bu. per acre.

Gain, 70.5 bu. per acre.

The average gain was 71.1 bu. per acre worth $28.44. Subtracting the expense of four sprayings, $4.13 per acre, we have *a net profit of* $24.31 *per acre.*

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[8] Both on same side of check; 642 lbs. and 653 lbs.

[9] One on either side of check; 715 lbs. and 754 lbs.

THE PLATTSBURGH EXPERIMENT.

Conducted by Pardy Bros., Plattsburgh, N. Y. Ten acres of potatoes (variety, Rose of Erin) were sprayed five times — July 1, 13, August 7, 30 and September 4. Two of the ten acres received one additional spraying on July 2. The spraying was done with a two-horse, six-row "Aroostook" sprayer carrying one nozzle per row. The bordeaux was of the 6–6–50 formula. The water required was pumped by hand and hauled about one hundred rods. A strip of six rows was left unsprayed for a check. These rows received five applications of paris green on the same dates that the sprayed rows received arsenite of soda with the bordeaux. Early blight, flea beetles, bugs, grass-hoppers, tip burn and spray injury were all factors in this experiment. In an attempt to destroy the hordes of bugs and grass-hoppers arsenite of soda stock solution was used with the bordeaux in the dangerously large quantity of 4 quarts to 50 gallons. As a consequence, the foliage was consideraby injured. Yet neither bugs nor grass-hoppers were controlled in a satisfactory manner.[10] The sprayed rows appeared somewhat better than the unsprayed, but the difference was not great.

The expense account contained the following items:

310	lbs. copper sulphate @ 5c	$15 50
1½	bbls. lime @ $1	1 50
85	lbs. sal soda @ 1c	85
42	lbs. white arsenic @ 10c	4 20
59	hrs. labor for man @ 17½c	10 33
38	hrs. labor for team @ 20c	7 60
	Wear of sprayer	7 50
	Total	$47 48

The test rows (400 ft. by 34 in.) yielded as follows:

One sprayed row, 190 lbs.= 121.9 bu. per acre.

One unsprayed row, 135 lbs.= 86.6 bu. per acre.

Gain, 35.3 bu. per acre.

The gain of 35.3 bu. had a value of $17.65. Subtracting $4.56, the expense of spraying, leaves *a net profit of* $13.09 *per acre.*

[10] Owing to the ravages of insects there is some doubt as to the propriety of including this experiment.

THE GREENWICH EXPERIMENT.

Conducted by P. C. Billings, Greenwich, N. Y. Six and one-half acres of potatoes were sprayed three times — July 30, August 12 and 24. In the first two sprayings the bordeaux used was of the 5–6–50 formula; in the third spraying, 6–6–50. The sprayer was a two-horse, six-row "Aroostook" carrying one nozzle per row. The water supply was nearby and the pumping done by a windmill. There were three check rows. They received four applications of paris green, while on the sprayed rows paris green was used only once. Bugs were kept under control. Tip burn was severe. Considerable damage was done by flea beetles, also, some by early blight; but there was no late blight and no rot. When last seen by one of the writers on September 4th the sprayed rows appeared slightly better than the unsprayed ones. Mr. Billings reports that before the close of the season there was considerable difference.

The items of expense were as follows:

100 lbs. copper sulphate @ 6½c	$6 50
100 lbs. lime @ 1⅓c	1 33
8 lbs. paris green @ 22½c	1 80
12 hrs. labor for man @ 20c	2 40
12 hrs. labor for team @ 30c	3 60
Wear on sprayer	2 50
Total	$18 13

Average expense of three sprayings, $2.79 per acre.

The test rows were of the variety Knoxall. They were 461 ft. long by 3 ft. wide. The yields were as follows:

Two sprayed rows,[11] 729 lbs. = 191.3 bu. per acre.

Middle unsprayed row, 355 lbs. = 186.3 bu. per acre.

Gain, 5 bu. per acre.

The expense of spraying being $2.79 per acre and the value of the increased yield (5 bu. at 50 cents) only $2.50, the spraying in this experiment appears to have been done at *a loss of* 29 *cents per acre.*

[11] One on either side of the check; 331 lbs. and 398 lbs.

THE GLENHEAD EXPERIMENT.

Conducted by G. T. Powell, Glenhead, Long Island. Fourteen acres of potatoes were sprayed five times on the following dates: June 15, 26, July 13, 26 and August 6. The sprayer used was a one-horse, four-row "Spramotor" carrying two nozzles per row. The bordeaux contained one pound of copper sulphate in each eight gallons. The facilities for the preparation of the bordeaux were convenient. The water was pumped by a gasoline engine from a well close by the potato field. A strip of four rows was left unsprayed for a check. Bugs were not troublesome. They were controlled on the sprayed rows by adding three quarts of arsenite of soda stock solution to each fifty gallons of bordeaux in the first two sprayings and on the check rows by one application of paris green made on June 15.

The contrast between sprayed and unsprayed rows was not great. There was no late blight. The important troubles were drought injury (tip burn) and flea beetle injury. The potatoes were of the variety Uncle Sam.

The expense account contained the following items:

375 lbs. copper sulphate @ 5c	$18 75
2 bbls. lime @ $1.25	2 50
100 lbs. sal soda @ 1¼c	1 25
20 lbs. white arsenic @ 10c	2 00
40 hrs. labor for man @ 20c	8 00
40 hrs. labor for horse @ 10c	4 00
Wear of sprayer	5 00
Total	$41 50

The test rows (560 ft. by 30 in.) yielded as follows:

One sprayed row, 310 lbs.= 160.7 bu. per acre.

One unsprayed row, 207 lbs.= 107.3 bu. per acre.

Gain, 53.4 bu. per acre.

Potatoes being worth seventy-five cents per bushel at digging time, the gain of 53.4 bu. had a value of $40.05. Subtracting the expense of spraying, $2.97 per acre, we have left *a net profit of* **$37.08.**

THE JAMESPORT EXPERIMENT.

Conducted by Henry A. Hallock, near Jamesport, Long Island. Twenty acres of potatoes were sprayed five times. The sprayer used was a one-horse, four-row Hudson sprayer carrying two nozzles per row. The dates of spraying were June 7, 20, July 9, 21 and 29. The bordeaux was made by the 7-4-50 formula. The water required was pumped by a gasoline engine and hauled ten to fifty rods. In the first two sprayings arsenite of soda was used with the bordeaux at the rate of four quarts of the stock solution to fifty gallons of bordeaux. There were four check rows. These received paris green twice — June 9 and 20. Throughout the season there was no perceptible difference, between sprayed and unsprayed rows. There was no blight, bugs did no damage and flea beetles were not troublesome. Apparently, there was nothing to spray for. The only trouble was dry-weather injury.

The expense account contained the following items:

700 lbs. copper sulphate @ 5c	$35 00
2 bbls. lump lime and 350 lbs. hydrated lime	6 75
200 lbs. sal soda @ ¾c	1 50
50 lbs. white arsenic @ 5¼c	2 63
5 days labor for man @ $2	10 00
5 days labor for horse @ $1	5 00
Wear on sprayer	5 00
Repairs on sprayer	2 50
Total	$68 38

The test rows (variety, Green Mountain) were 455 ft. long by 3 ft. wide. They yielded as follows:

Two sprayed rows,[12] 409 lbs.=108.8 bu. per acre.

Two unsprayed rows, 349 lbs.=92.8 bu. per acre.

Gain, 16 bu. per acre.

At the time of digging the test rows the market price of potatoes was seventy-five cents per bushel. At this price sixteen bushels have a value of $12. After subtracting the expense of spraying, $3.42 per acre, there remains ***a net profit of* $8.58 *per acre.***

[12] One on either side of check.

THE SOUTHAMPTON EXPERIMENT.

Conducted by Lewis E. Downs, Southampton, Long Island. Sixty-seven acres of potatoes were sprayed eight times with a two-horse, six-row "Aroostook" sprayer carrying one nozzle per row. The dates of spraying were June 21, 26, July 3, 9, 14, 20, 27 and August 2. The bordeaux used was prepared by the formula, six pounds copper sulphate in fifty gallons of water with sufficient lime added to satisfy the potassium ferrocyanide test. It was necessary to haul water about forty rods. An engine was used in pumping it. In two sprayings (the first and third) three quarts of arsenite of soda stock solution were added to each fifty gallons of the bordeaux. There were four unsprayed rows which were treated twice with paris green — on June 26 and July 2. There was no late blight, but early blight, tip burn and flea beetles were plentiful. During the latter part of the growth period the check rows were so much inferior to the sprayed ones that the contrast was very marked.

The expense of spraying sixty-seven acres eight times was as follows:

3,081 lbs. copper sulphate @ 5½c	$169 45
3,081 lbs. lime @ 1c	30 81
600 lbs. sal soda @ 1c	6 00
150 lbs. white arsenic @ 5c	7 50
3 days labor (preparing arsenic solution) @ $3	9 00
24 days labor for man @ $2	48 00
24 days labor for team @ $2	48 00
Wear on sprayer	10 00
Wear on tanks and pumping outfit	5 00
Total	$333 76

The test rows were of the variety Carman No. 1. They were 1,200 feet long by 33 inches wide. The yields were as follows:

Two sprayed rows, 2,270 lbs.= 249.7 bu. per acre.

Two unsprayed rows, 1,670 lbs.= 183.7 bu. per acre.

Gain, 66 bu. per acre.

The market price of potatoes at digging time was sixty-five cents per bushel. Accordingly the gain of sixty-six bu. had a value of $42.90. After deducting the expense of spraying, $4.98 per acre, there remains *a net profit of* $37.92 *per acre.*

SUMMARY OF BUSINESS EXPERIMENTS IN 1909.

TABLE XX.— SHOWING RESULTS OF BUSINESS EXPERIMENTS IN 1909.

EXPERIMENT.	Area sprayed.	Number of times sprayed.	Increase or decrease in yield per acre.	Total cost of spraying per acre.	Cost per acre for each spraying.	Net profit or loss per acre
	A.		Bu.			
Southampton	67	8	66.	$4 98	$0 62	$37 92
Glenhead	14	5	53.4	2 97	60	37 08
Chateaugay	12	4*	71.1	4 13	1 03	24 31
Plattsburgh	10	5	35.3	4 56	91	13 09
Jamesport	20	5	16	3 42	68	8 58
Sterling Station	14.44	6–7	29.8	5 85	90	7 56
Ogdensburg	5.7	7	18.1	5 53	79	3 52
Elmira	22	2	6.9	1 65	83	1 80
Greenwich	6.5	3	5.	2 79	93	— 29
Batavia	15	6	—1.6	3 ·71	62	—4.51
Victor	12	8†	—1.6	6 27	78	—6.91
East Syracuse	4.5	3	—6.	3 99	1 33	—7.59

* Test rows sprayed four times, balance of field, three times.
† Test rows double-sprayed four times, balance of field twice.

Average increase in yield per acre, 24.4 bushels.
Average net profit per acre, $9.55.

SUMMARY OF BUSINESS EXPERIMENTS, 1903–1909.

TABLE XXI.— SHOWING RESULTS OF BUSINESS EXPERIMENTS, 1903-1909.

YEAR.	Number of experiments.	Total area sprayed.	Average increase in yield per acre.	Average total cost of spraying per acre.	Average cost per acre for each spraying.	Average net profit per acre.
		A.	Bu.			
1903	6	61.2	57	$4 98	$1 07	$23 47
1904	14	180	62.2	4 98	93	24 86
1905	13	160.7	46.5	4 25	98	20 04
1906	15	225.6	42.6	5.18	985	13 89
1907	14	152.75	36.8	5 90	1 18	17 07
1908	14	200.25	18.5	4 30	92	8 53
1909	12	203.14	24.4	4 15	835	9 55

Average increase in yield, for seven years, 41.1 bu. per acre.
Average net profit, for seven years, $16.77 per acre.

VOLUNTEER EXPERIMENTS.

In 1904 the Station began collecting and recording the results of potato spraying experiments made by farmers in all parts of the State. As these experiments are carried out entirely by the farmers themselves we call them volunteer experiments. It is probable that, in some cases, the yields, expense of spraying and other data given for the volunteer experiments are not as accurate as are those given for the farmers' business experiments. Nevertheless, they are valuable. They supplement the regular business experiments. By bringing together the results of a large number of business experiments and volunteer experiments extending over several consecutive seasons the Station hopes to be able to answer definitely the question, Does it pay to spray potatoes in New York? We are under obligations to the many farmers who have assisted in this work and take this opportunity to express our appreciation of their services. The experiments are to be continued at least two years longer and it is hoped that we may continue to have the hearty coöperation of potato growers throughout the State. All who spray potatoes with bordeaux mixture are requested to leave a few rows unsprayed in order that it may be determined how much the yield is increased by spraying. The product of unsprayed and sprayed rows adjacent should be *weighed or measured* and the length of the rows measured so that the yields may be accurately determined. We cannot use experiments in which the yields have been only estimated. Neither can we use experiments in which the application of poison to the unsprayed rows has been neglected.

The following table shows the principal results of the twelve volunteer experiments reported in 1909:

TABLE XXII.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN 1909.

Experiment.	LOCATION.	Name.	Area sprayed.	Times sprayed.	YIELD PER ACRE.		Gain per acre due to spraying.	Cost per acre each spraying.	Price of potatoes.	Kind of sprayer.
					Sprayed.	Not sprayed.				
			A.		Bu.	Bu.	Bu.	Cts.	Cts.	
1	Canton..........	H. E. Cook.....	6.5	9	376.2	248.5	127.7	107	40	8-row, 2-horse, Mascot.
2	Fayetteville......	F. E. Dawley...	7	5	322.7	198	124.7	......	60	4-row, 2-horse, Watson.
3	West Rush......	T. E. Martin....	18	?	314.5	255	59.5	......	50	6-row, 1-horse, home-made.
4	Lancaster.......	F. W. Handy...	9	5	204.3	158.7	45.6	......	60	4-row, 2-horse, Iron Age.
5	Dewittville......	G. A. Kirkland..	5.5	6	166.9	122.1	44.8	117	50–60	4-row, 1-horse, Spramotor.
6	Phelps..........	J. L. Salisbury..	12	4	140.2	96.7	43.5	104	45	6-row, 2-horse, Aroostook.
7	Spencerport.....	F. E. Gott......	12	3	285.6	257.6	28	......	40	4-row, 1-horse, Aspinwall.
8	Dryden.........	D. R. Trapp....	8	6	288	264	24	......	50	4-row, 2-horse, Iron Age.
9	Memphis........	M. Bowes.......	12	4	228.7	207.8	21	86	45	4-row, 1-horse, home-made.
10	La Fargeville....	F. Lantier......	15	4	106.1	95.5	10.6	......	50	4-row, 1-horse, Watson.
11	Peru............	J. Mannix......	4	3	125.9	122.8	3.1	60	50	5-gallon, compressed air.
12	Cutchogue.......	W. W. Sterling..	6	4	338.8	338.8	0	......	60–75	4-row, 1-horse, Hudson.

ADDITIONAL NOTES ON THE VOLUNTEER EXPERIMENTS IN 1909.

Experiment No. 1. This experiment was conducted on the farm of the New York State School of Agriculture at St. Lawrence University, Canton, N. Y. The chief features of the experiment are the thoroughness of the spraying and the remarkably large increase in yield when tip burn was the only important foliage trouble present. In nine applications the total quantity of bordeaux used was 875 gallons per acre.[13] The pumping was done by a 3 H. P. " Mascot " gasoline engine and a high pressure (75 to 100 lbs.) maintained.

The total expense of spraying was $9.49 per acre, the items being as follows:

Labor	$2 64
Copper sulphate	5 50
Lime	35
Wear of sprayer	1 00
Total	$9 49

With potatoes selling at 40 cents per bushel the net profit from spraying was $41.57 per acre.

Experiment No. 2. The chief troubles affecting the foliage were tip burn and flea beetles. The materials required for spraying were " most of one barrel of lime, 40 lbs. arsenate of lead and about 120 lbs. of copper sulphate." At each application one man and a team did the spraying all in one day.

Experiment No. 3. The exact number of applications is uncertain, but it is known that the total quantity of bordeaux used on 18 acres was 18,425 gallons, which is at the rate of 1,023½ gal-

[13] An account of this experiment has been published previously ([Cook, H. E.] Circular of information of the New York State School of Agriculture at St. Lawrence University, Canton, N. Y. *University Bulletin*, Series 4, No. 2, pp. 49–51. Apr. 1910.) On page 51 of this publication there is a table which purports to show the number of gallons of bordeaux applied per acre in each spraying, the total being 4175 gallons. Dean Cook informs us that this is an error and that the quantities given are for the entire field (nearly five acres) not per acre

lons per acre. The items of expense for spraying 18 acres throughout the season were as follows:

1,675 lbs. copper sulphate @ $4.85 per cwt	$81 24
Freight on copper sulphate	2 01
15 bbls. Ohio lime	15 75
25 days labor for man and horse @ $3	75 00
Total	$174 00

Total expense of spraying per acre, $9.67.

There was no blight, but flea beetles were very troublesome and considerable damage was caused by tip burn. The market price of potatoes being 50 cents per bushel the net profit from spraying in this experiment was $20.08 per acre. Five rows which were double sprayed, receiving 2,047 gals. per acre, yielded at the rate of 27 1/5 bu. more than single-sprayed rows and the net profit was thereby increased to $24.01 per acre. But, one row which was triple-sprayed, receiving 3,070 gals. per acre, yielded at the rate of 25½ bu. per acre *less* than unsprayed rows. It is unlikely that this reduction in yield was due to spraying, but the real cause is unknown.

Experiment No. 4. There was no blight, but flea beetles were plentiful.

Experiment No. 5. Tip burn, which was quite prevalent, appeared to be considerably checked by spraying. There was no late blight and flea beetles were not particularly troublesome. The expense of spraying was as follows:

266 lbs. copper sulphate @ 5½c	$14 63
17½ lbs. paris green @ 22½c	3 94
6 sacks lime @ 25c	1 50
74 hrs. labor for man and horse @ 25c	18 50
Total	$38 57

Experiment No. 6. Mr. Salisbury doubts that the difference in yield of sprayed and unsprayed rows was all due to spraying. Although poison was applied to the unsprayed rows twice and

seemed very effective in destroying the bugs, the unsprayed rows may have been injured a little more by bugs than were the sprayed rows. However, it appears that the difference was not great enough to warrant the rejection of the experiment. There was no late blight, but flea beetles were numerous.

Experiment No. 7. There was no blight and but few flea beetles in this experiment.

Experiment No. 8. Tip burn was more injurious on the unsprayed than on the sprayed rows. The unsprayed rows were not injured by bugs, there were few flea beetles and no blight. The expense for spraying materials was as follows:

240 lbs. copper sulphate @ 6c	$14 40
30 lbs. paris green @ 25c	7 50
300 lbs. lime	1 80
Total	$23 70

Experiment No. 9. In the eight-acre field containing the test rows the total cost of four sprayings was $27.64 for labor and materials. There were four unsprayed rows 643 feet long. The amount of the increase in yield due to spraying was computed from the difference in yield between the middle two unsprayed rows and the second and third sprayed rows on either side as follows:

Two sprayed rows on the left, 1,206 lbs.
Two sprayed rows on the right, 1,226 lbs.
Middle two unsprayed rows, 1,106 lbs.
There was no blight and but few flea beetles.

Experiment No. 10. Tip burn was quite general, but there was no blight and flea beetles were not troublesome.

Experiment No. 11. The plants were free from blight and flea beetles.

Experiment No. 12. At one end of the field where there had been potatoes the previous year, some kind of blight injured the

unsprayed rows somewhat more than the sprayed ones. Flea beetles were plentiful. Yet there was no difference in yield. Two unsprayed rows 600 feet long yielded 14 bushels while two sprayed rows adjacent on the west side yielded 13½ bushels and two other sprayed rows adjacent on the east side yielded 14½ bushels.

SUMMARY OF VOLUNTEER EXPERIMENTS, 1904–1909.

The following table shows the results obtained in the volunteer experiments during the past six years — 1904 to 1909, inclusive:

TABLE XXIII.— SHOWING RESULTS OF VOLUNTEER EXPERIMENTS, 1904–1909.

YEAR.	Number of experiments.	Total area sprayed.	Average gain per acre due to spraying.		Average market price per bushe of potatoes at digging time.
		A.	*Bu.*	*lbs.*	*Cts.*
1904	41	364	58	28	43.5
1905	50	407	59	32	57.0
1906	62	598	53	6	44.5
1907	24	264	30	28	58
1908	11	74	66	18	66
1909	12	115	44	22	51

Average gain for 6 *years* (200 *experiments*), 52 *bu. per acre.*

POTATO TROUBLES IN NEW YORK IN 1909.

Over the entire State the season of 1909 was a very dry one. At Geneva the total rainfall from June 1 to October 1 was 8.64 inches, the least amount recorded since 1882. Consequently, tip burn, or the browning of the tips and margins of the potato leaves, was widespread and caused much damage. Next in importance were the flea beetles which, in many cases, were very numerous and destructive. The browning of the leaves due to the combined effect of tip burn and flea beetle injury was frequently mistaken for blight. Of the real potato blight there was but little. Traces of early blight (*Alternaria solani*) occurred in a considerable num-

ber of fields, but it was destructive in only a few instances. Late blight (*Phytophthora infestans*) and the rot which follows it were entirely absent. The writers realize that a positive statement of this kind can rarely be made with assurance of its accuracy, but in the present case the circumstances seem to warrant it. We neither saw nor heard of any late blight or Phytophthora rot any where in the State, not even on Long Island where the disease occurs almost every year. Moreover, in the latter part of the season the weather was so uniformly dry as to preclude the possibility of the occurrence of late blight.

DIRECTIONS FOR SPRAYING.[14]

In general, commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of 10 to 14 days in order to keep the plants well covered with bordeaux throughout the season. During epidemics of blight it may be necessary to spray as often as once a week. Usually six applications will be required. The bordeaux should contain four pounds of copper sulphate to each 50 gallons in the first two sprayings and six pounds to 50 gallons in subsequent sprayings. Whenever bugs or flea beetles are plentiful add one to two pounds of paris green or two quarts of arsenite of soda stock solution to the quantity of bordeaux required to spray an acre.

Thoroughness of application is to be desired at all times, but is especially important when flea beetles are numerous or the weather favorable to blight. Using the same quantity of bordeaux, frequent light applications are likely to be more effective than heavier applications made at long intervals; e. g., when a horse sprayer carrying but one nozzle per row is used, it is better to go over the plants once a week than to make a double spraying once in two weeks. A good plan is to use one nozzle per row in the early sprayings and two nozzles per row in the later ones.

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[14] Copied from Bulletin No. 290, p. 320. The experiences of the past three seasons do not warrant any material alteration in the recommendations there made.

Those who wish to get along with three sprayings should postpone the first one until there is danger of injury from bugs or flea beetles and then spray thoroughly with bordeaux and poison. The other two sprayings should likewise be thorough and applied at such times as to keep the foliage protected as much as possible during the remainder of the season. Very satisfactory results may be obtained from three thorough sprayings.

A single spraying is better than none and will usually be profitable, but more are better. Spraying may prove highly profitable even though the blight is only partially prevented. It is unsafe to postpone spraying until blight appears. Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects use bordeaux mixture and poison together.

MEDULLARY SPOTS: A CONTRIBUTION TO THE LIFE HISTORY OF SOME CAMBIUM MINERS.*

J. G. GROSSENBACHER.

SUMMARY.

While studying a disease of currants in the Hudson Valley, dark streaks, which appear as spots in cross section, were often found in the canes. It soon became evident that they were due to some miner. The causal insect-larva and its adult or perfect form were finally secured during the past summer. The miner proved to be the early stage of a tiny moth belonging to a group none of the larvæ of which had been found before.

Somewhat similar larvæ were found mining under the bark of both wild and cultivated species of plum and cherry, and some hawthorns. They hibernate under the bark and therefore their adults can not be obtained until next summer. What seem to be members of this group of miners have been obtained and described before, but their adult forms were not secured and consequently it is impossible to say, as yet, even though they were said to belong among the flies, just where they belong.

The economic relations of these insects may prove of some importance, for the currant miner has been shown to afford entrance to a fungus which is thus enabled to kill gooseberry shoots. Direct injury to currants and gooseberries is probably not very serious and of course the direct injury to plums, cherries, etc., by other cambium miners is no doubt even less, because the mines are so small when compared to the size of the plants.

*A reprint of Technical Bulletin No. 15.

INTRODUCTION.

In making a rather detailed life-history study of a fungus which causes a blight of *Ribes vulgare* dark-brown streaks were commonly observed in living young canes during late summer. Streaks or mines of the same type were also found in *R. nigrum* and *R. Grossularia.* No causal insect was obtained during the first few seasons, but some literature on somewhat similar streaks occurring in various trees was finally found. During the past summer causal insect-larvæ were secured from both Ribes and trees, but the Ribes-miners differed much from the tree-miners, though superficially they appear similar. Those from Ribes proved to be caterpillars of a tineid moth and were identified by A. Busck as *Opostega nonstrigella* Ch. Since no larvæ of the genus Opostega had been known, these observations may lead to further discoveries. The tree cambium-miner seems to be of the type found described in some botanical literature. However, their imagines have not as yet been obtained; and though Ratzeburg and others have suggested that they are tipulids, they probably belong elsewhere.

A HISTORICAL VIEW OF MEDULLARY-SPOTS AND THEIR CAUSE.

Th. Hartig[1] found what he called cellular-channels usually present in the wood of Betula, most often extending from the roots 1.2 — 1.5 m. up the trunk. He observed fewer of them in Corylus and Alnus. The streaks were composed of thick-walled porose, starch-bearing cells and brown masses of an unknown substance which was said to be insoluble in both water and alcohol. Plate VIII, figure 3 is a reproduction of his illustration from a cross section of *Alnus incana.*

[1] Hartig, Th. Vollständige Naturgeschichte der forstlichen Culturpflanzen Deutschlands, pp. 228, 326 and 336. Berlin: 1851.

In 1853 Ratzeburg[2] received, from Russia, some wood from thirty-year old birch trees which had these channels in practically every year's growth; and also some insect larvæ which had been found under their bark and suspected as the cause of the mines. Upon examination Ratzeburg provisionally named the larvæ *Tipula suspecta* though he thought it improbable that the mines had been made by them. Drawings made from the birch wood are reproduced on Plate VIII, figures 7 and 7a.

In a very brief, critical review of some literature on medullary-spots, by de Bary,[3] the most striking histological characteristics are given and it is held that they are simply local hypertrophies of medullary rays. The review is perhaps based principally on Kraus' comparative histological work on the subject.[4]

These spots have also been made use of by several writers as one of the specific characters to distinguish the wood of forest trees.[5]

Cambium miners the cause of medullary-spots.— Perhaps the most important and complete discussion of the literature, cause and development of medullary-spots is given by Kienitz.[6] The making of his key to distinguish woods by these spots led him to study the matter more in detail and as a result some pertinent objections to viewing them as normal structures became evident to him. He found, as had some preceding him, that the spots were confined mostly to the basal part of stems and were not present in all trees of a species nor always in every year's growth of a tree which has them. These irregularities and the characteristic histology of a medullary-spot, with the more or

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[2] Ratzeburg, J. T. C. Waldverderbniss **2**: 228–29. Berlin: 1868.

[3] de Bary, A. Vergleichende Anatomie der Vegetationsorgane der Phanerogamen und Farne, pp. 507–8. Leipzig: 1877.

[4] Kraus. Bau der Nadelhölzer. *Würzburger naturwissenschaftliche Zeitschrift*, vol. **5**.

[5] Hartig, R. Die Unterscheidungsmerkmale der wichtigeren in Deutschland wachsenden Hölzer. München: 1879.

Kienitz, M. Schlüssel zum Bestimmen der wichtigsten in Deutschland culti vierten Hölzer. Munchen: 1879.

Nördlinger. Anatomische Merkmale der wichtigsten deutschen Wald- und Gartenholzarten. Stuttgart: 1881.

[6] Kienitz, M. Die Entstehung der Markflecke. *Bot. Centbl.* **14**: 21–26, 56–61. 1883.

less structureless brown line separating it from some adjoining, normal wood tissue, and the total lack of any radial arrangement of its cells, lead him to infer that they were not developed from the cambium in a normal manner. Finally, the finding of insect-larvæ in fresh mines under the bark of some species forced him to the conclusion that medullary-spots of various deciduous trees are occluded channels which had been mined in the cambial cylinder by insects.

The larvæ were found in Amelanchier, Sorbus, Salix and Betula and were considered to be the same species because they were indistinguishable. The eggs were thought to have been laid singly in or on the bark from which the filiform larvæ mined groundward, increasing but little in diameter but much in length. After making one or more return trips of various lengths up and down under the bark they attained a length of 2—3cm. before boring their way out through the bark to pupate in the ground, where it is supposed the winter is passed. An *observed* exit of a larva is shown in Plate IX, figure 4a. Though the larvæ from Salix shoots entered moist sand, into which the twigs were stuck, no imagines emerged. Some of the preserved miners were submitted to Gerstäcker for identification, and he reported that they were undoubtedly dipterous larvæ. Only one brood was found, and but one set of channels was observed in the wood of any year's growth.

The mines were found to be very small and cylindrical at their beginnings and, as the miners advanced, to increase gradually in both their radial and tangential diameters; though the former never exceeded that of the larvæ much, the latter were often several times greater, by the time the miners neared the end of the larval stage, as shown in Plate IX, figure 2, which is copied from Kienitz's illustration. The medullary-spots were found present in species of Alnus, Betula, Corylus, Salix, Sorbus, Cratægus and Prunus.

The configuration of channels varied, but yet the mines were essentially the same. In all observed cases the first mining

seemed to have been groundward some distance, and then, after facing about in the unwidened mines, the larvæ veered to the right or left, mining return channels upward 20—30 cm. or more and often nearly parallel to the downward channels, when similar returns are made downward. The length of the narrow end-turns usually exceeded the length of the larvæ but little, as shown in figures 2 and 3, Plate IX. It seemed that the number of returns made and the distance between them depended upon the amount of available food encountered. As stated before, and as may be seen from the illustration cited, the channels increase in size as larvæ get older, especially in tangential diameter and therefore in cross-section the smaller, narrower spots are found nearer the beginning and the larger, wider and more crescent-shaped ones nearer the end of a year's growth. (Plate IX, fig. 8.) However the quantity of food available also seemed to influence the tangential diameter.

Kienitz thought that the larvæ use their hook-like mouth parts to rupture cells and then devour their contents, and in advancing push aside the walls of the ruptured cells and thus form channels. The histological modifications which follow were studied in a Salix shoot containing a nearly full-grown larva. Three medullary-spots were found in a cross section taken from the twig near the anal end of the miner; the smallest spot was near the pith and the largest one in the cambial region, as shown in figures 7 and 8 on Plate IX. Since cambial activity continues unchecked on both sides of a mine its radial diameter increases after the larva has passed. But some uninjured cells on the cortical side of a channel soon proliferate, bladder-like, into the cavity and also regenerate a bridge of normal cambium across the gap. The bark ray-cells were found the most important and almost the exclusive regeneration centers, though cortical parenchyma and wood ray-cells were also observed to take part in the process. The discoloring cell fragments and frass were compressed into irregular brown masses by the rapid growth and division of the regeneration cells. The growth-pressure in the occluding channels became sufficient

to produce compressed irregular-celled "medullary" tissue with thickened, pitted walls, which contained starch in abundance.

For some unknown reason these observations by Kienitz remained unfinished and became obscured; neither botanists nor entomologists seem to have paid much attention to them, and as a result some unfortunate errors developed. Haberlandt[7] says that medullary-spots are to be considered primarily as storage tissue because they contain starch and tannin; while Sorauer,[8] though giving some prominence to Kienitz's work, treats the matter under the general head of injurious or sub-optimal temperatures.

A CAMBIUM MINER OF RIBES.

DISCOVERY AND STUDY.

Introduction.— During late summer of 1907, large numbers of rank-grown currant shoots (*Ribes vulgare*), in some regions of the Hudson River valley, had their distal portions defoliated while other leaves were still green. Many such shoots were found to have pairs of more or less parallel dark streaks in the outer wood, extending lengthwise the canes from 7—18 cm. Upon carefully removing all of the bark and outer wood to the full length of a pair, they were found to form one continuous line which had well-rounded turns at both its distal and proximal ends. The distance between such a pair of brown streaks generally varied from 2—7 mm. and the diameter of a line was about .7 mm. It seemed that a very slender mine had been made in the cambial region and that the adjoining meristematic tissue had proliferated cells into the channel, which became dark colored. (See Plate VI, fig. 1.) No insect was found in the streaks during the first season.

These observations were repeated earlier in 1908 and 1909, but no insects were noticed in the mines. However it was found

[7] Haberlandt, G. Physiologische Pflanzenanatomie (4te Aufl.), p. 606. Leipzig: 1909.

[8] Sorauer, P. Handbuch der Pflanzenkrankheiten (3te Aufl.), 1: 611. Berlin: 1909.

that in some places as high as 10—60 per ct. of the currant canes contained one or more of the mines and that older, diseased or blighted plantations and others adjoining them, had a much higher percentage of their canes mined than plantations which were young and scattered. In certain regions of this State, where currant patches are few and small, no mined canes were observed.

Discovery of the causal insect.— On May 17, of this year, the bark was carefully removed from large numbers of vigorous currant shoots in a blighted plantation near Milton, N. Y., and, though no mines or discolorations were found under the bark, finally a very tiny, brown point which proved to be the head of a thread-like larva with a whitish body, was observed on the greenish-white surface of a decorticated shoot. It was comparatively easy to find anywhere from one to five larvæ in at least 50 per ct. of the shoots in that particular plantation, after once their appearance was known. The largest larvæ were found mining under the bark of the former season's growth and especially across the transition of last year's to this year's growth, while those found farther up (distal) were much smaller and probably younger, some being but little over 3 mm. in length. The mines of the largest larvæ had browned sufficiently to be readily traced, but those of the smaller ones were not discolored and therefore were not visible even with a lens.

A few days later great numbers were found in a large and rather crowded plantation, of *Ribes vulgare, R. nigrum* and *R. Grossularia,* planted among fruit trees, in Rochester, N. Y. By making cross-sections of 2 to 5-year old canes it became evident that they all had been mined more or less each season, as the presence of a pair of dark spots in the different annual wood-rings indicated. Many of the large *R. nigrum* bushes had the larvæ present in 85—95 per ct. of their canes, while *R. vulgare* and *R. Grossularia* in about 40—65 per ct. But in some parts of the plantation *R. nigrum* seemed to be entirely free from cambium miners, and the other species had but very few.

Obtaining pupæ and imagines of the Ribes miner.— On June 8, a large bundle of *R. vulgare* and *R. nigrum* canes from the

Rochester plantation were stuck into a box of sterile wet soil and put inside a cheese-cloth cage in one of the Experiment Station greenhouses. Ten days later the larvæ in the Rochester plantation seemed to be about full-grown and therefore, after replacing the top 5—7 cm. of soil about them with soil obtained 5—7 cm. below the surface from between the rows, cheese-cloth cages were built about two bushes of *R. nigrum* and one of *R. vulgare.*

No larvæ were found in any of the species of Ribes on June 28; however a more or less crescent-shaped hole, closed by a dark plug in currants but left open in many gooseberries, could always be found near the proximal turn of a mine, opening from the channel to the exterior through the bark. (See Plate VII, fig. B 3). On the following day, it was found that the few larvæ which survived in the dying canes put into a box of soil had also come out, but they were lying on the surface of the wet soil, dead, making it seem probable that they pupate in the ground but that this was too wet for them. On July 2 no insects were seen in the cages at Rochester, but about fifteen brownish, seed-like cocoons, obtained by sifting some of the surface soil, from within a cage about a *R. nigrum* bush, were finally collected into a vial. A lepidopterous pupa and the cast skin of the *cambium-mining larva* were in each of a number of cocoons opened. Eight days afterward only empty cocoons were found in the soil and all but one of the cocoons remaining in the vial were vacated but the last larval moult with its characteristic head markings was found in them. The vial contained a few living and a number of dead tineid moths. But no moths were found during the day time, either in the remaining cages or out among other currant bushes. Since the cocoons always contain the last moult, and were also found abundant under uncaged Ribes plants, the connection of the larval with the imago stage is convincing even without the precautions taken in the preparation of the cages as described above.

Summary of facts found about the life history.— From these observations it seems probable that the eggs are laid in or on the bark of Ribes from about the last week of April to nearly the

PLATE V.—*Ribes vulgare*. SHOOT CONTAINING OPOSTEGA LARVÆ. Two small larvæ were found in it, May 17, 1910, one distal to the other.

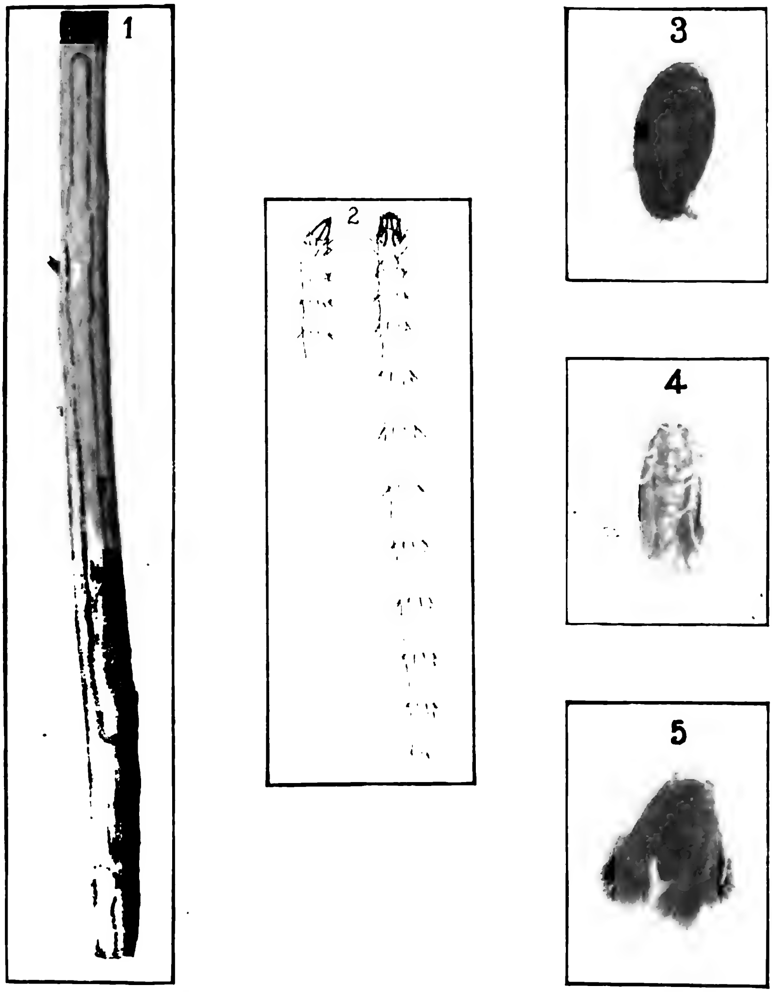


PLATE VI.—WORK AND APPEARANCE OF *Opostega nonstrigella* CH.

1. *Ribes vulgare* twig with a complete distal channel and a portion of a proximal one.

2. Dorsal and lateral views of a larva, 12.5 mm. long. (Camera lucida drawing.)

3. Cocoon. 4. Ventral view of moth.

5. Dorsal view.

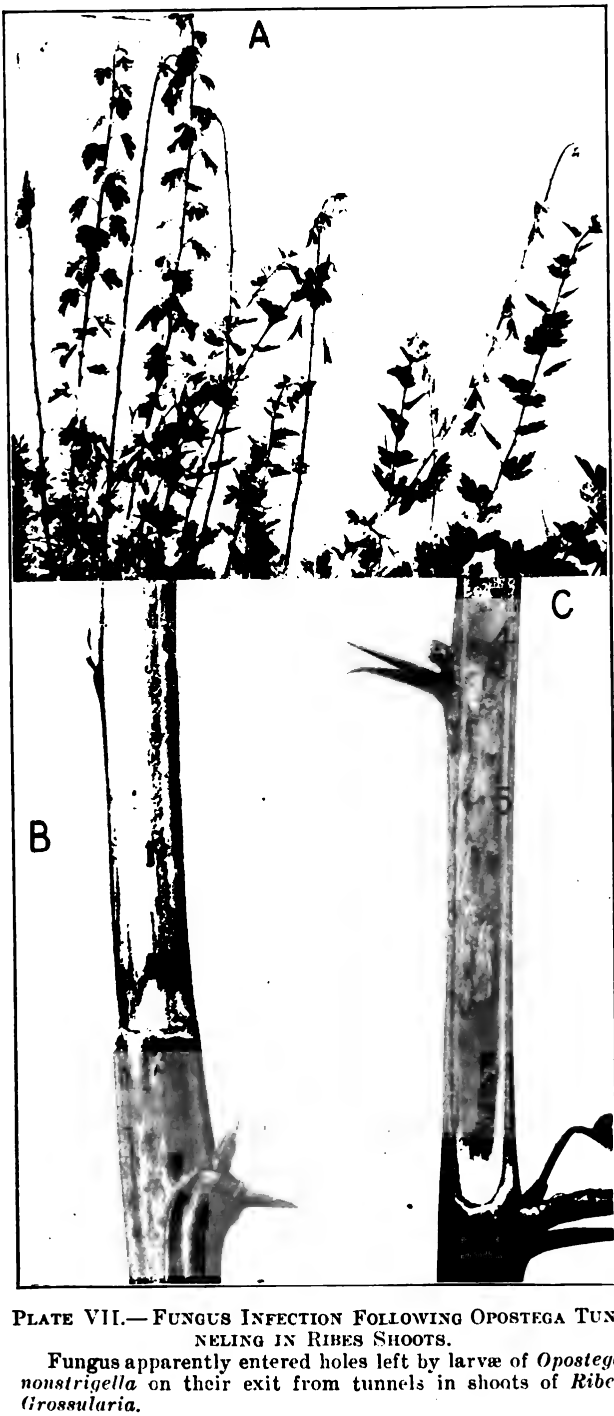
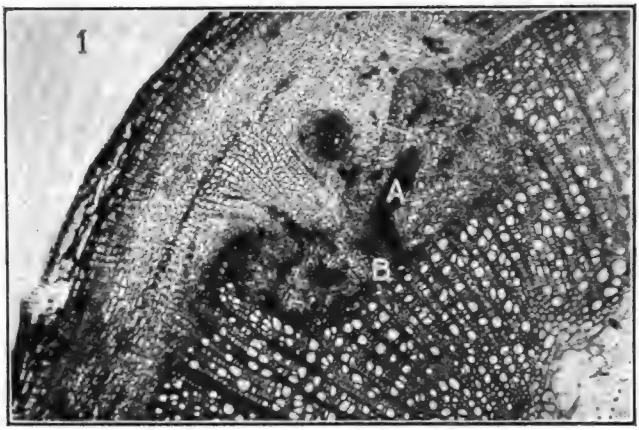
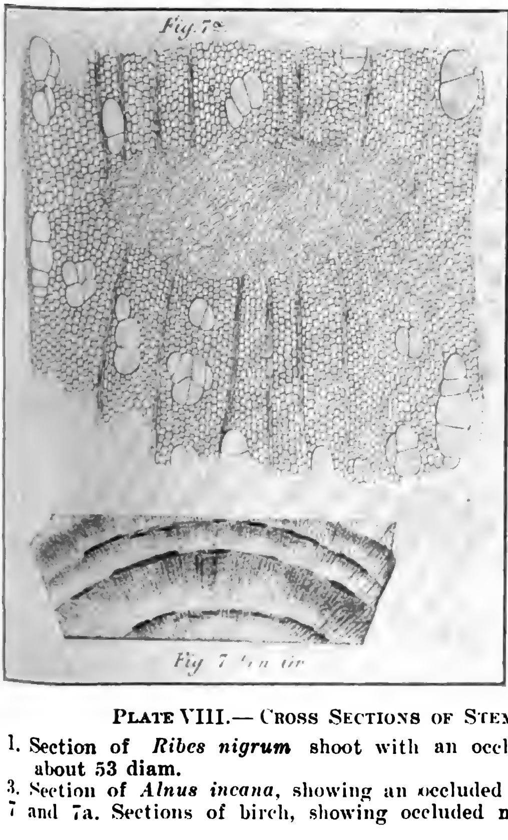


PLATE VII.—FUNGUS INFECTION FOLLOWING OPOSTEGA TUNNELING IN RIBES SHOOTS.

Fungus apparently entered holes left by larvæ of *Opostega nonstrigella* on their exit from tunnels in shoots of *Ribes Grossularia.*

(See detailed explanation on back of Plate IX.)





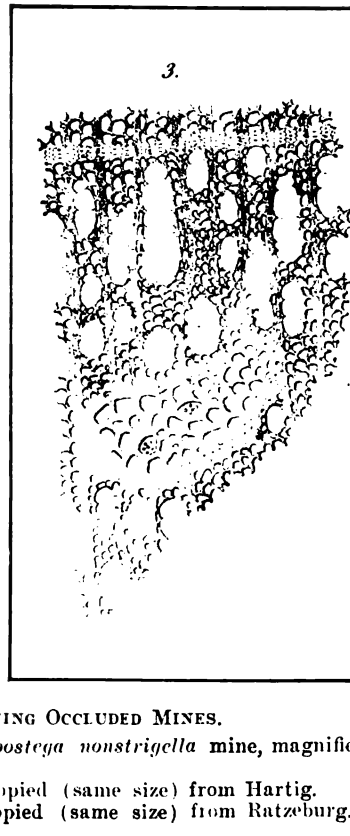
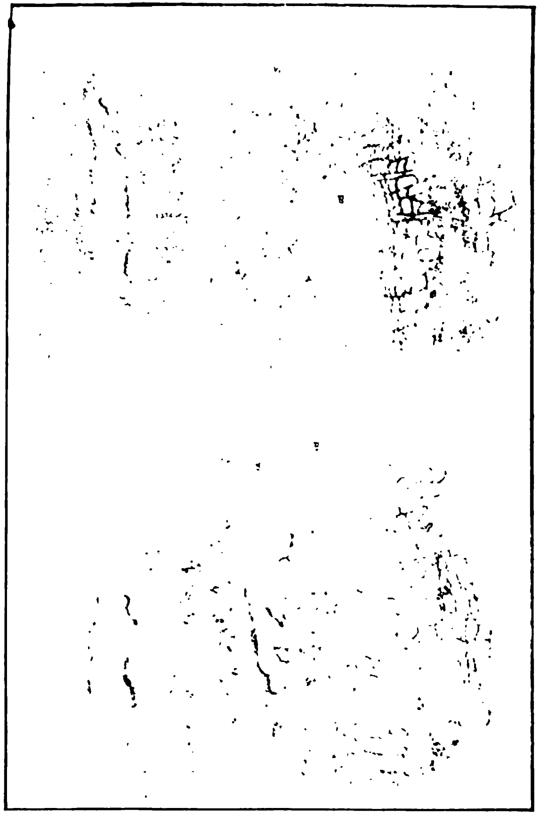
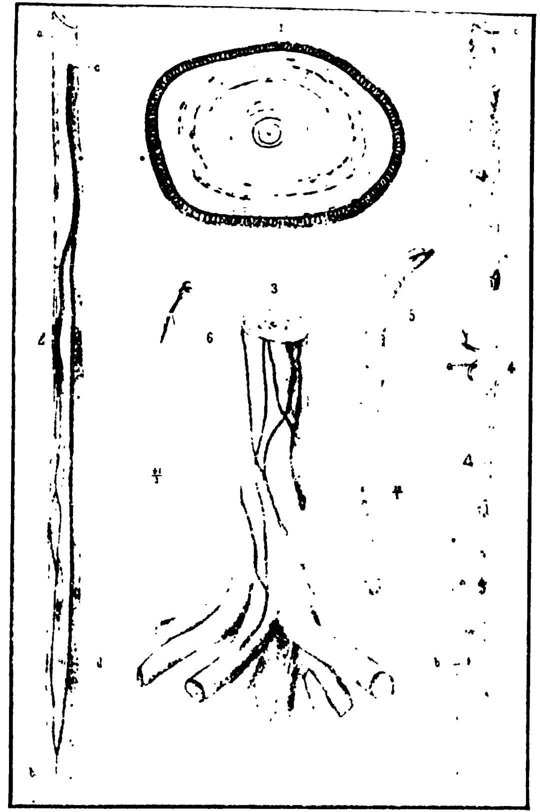


Plate VIII.— Cross Sections of Stems Showing Occluded Mines.

1. **Section of *Ribes nigrum* shoot** with an occluded *Opostega nonstrigella* **mine, magnified about 53 diam.**
3. Section of ***Alnus incana***, showing an occluded mine, copied (same size) from Hartig.
7 and 7a. Sections of birch, showing occluded **mines**, **copied (same size)** from Ratzeburg.



(From Kienitz; about $\frac{2}{3}$ original size.)



(From Kienitz; about $\frac{1}{2}$ original size.)

PLATE IX.—CHANNELS IN SORBUS, BETULA AND SALIX, WITH CAUSAL LARVÆ.

(See back of Plate.)

Plate VII, *continued.*— A. All shoots with recurved distal ends are either dead or have each a dead section (as shown in C) somewhere between the ground and their wilted tips.

B. Shoot enlarged, showing (1) a mine or streak in its *living* distal part; (2) a dead section or region, and (3) an exit-hole of the larva.

C. A similar shoot with (4) living, normal pith and (5) discolored, dead pith.

Plate IX, *continued.*— 1. Cross section of *Betula pubescens* stem, showing numerous medullary spots in its different annual growths.

2. Decorticated shoot of *Salix rubra* with a streak of a larva (said to be dipterous).

a. Starting point of the streak; b. first turn; c, second turn, and d, head of ¾-grown larva in its channel in the cambium (natural size).

3. Basal end of *Sorbus aucuparia* stem, with proximal end-turns of three channels. Medullary spots in its cross section (natural size).

4. Shoot of *Salix rubra.*

a. An emerging larva; b, an exit-hole; c, cross section of the channels (medullary spots).

5. A larva (said to be dipterous) which is about half grown.

6. Head of a similar larva.

7. Cross section through the younger wood and cortex of a *Salix rubra* shoot with part of a recently-made channel, showing the beginning of regeneration; a, frass.

8. A later stage in which regeneration has made marked progress, showing proliferation occurs from the cortical side and from the medullary rays of the wood. A completely occluded mine, by the same larva, occurs deeper in the wood; a, and b, lignified cortical cells.

9. A fully occluded, somewhat crescent-shaped channel.

middle of May, and that the larvæ mine in the cambial cylinder about four to six weeks or till about June 18 to 28; while the pupal stage is passed in the ground and seems to last about two to three weeks, ending by July 10. The reason for assuming that the eggs are laid on Ribes in spring rather than the preceding season is that the larvæ are present in the cambium of both the older canes and that of spring shoots. Those mining in older canes or across the transition from last season's to the spring growth, were always found to be larger during May, than the ones having mines wholly in this season's growth. In fact, about the middle of May, the larvæ near the distal end of this season's growth were smaller and seemed younger than those nearer its proximal end. The inference seems to be that oviposition begins on the older canes shortly before the new shoots develop, i. e., during the latter part of April, and continues till nearly the middle of May; because on May 17 some larvæ were found which measured only about 3 mm. in length. It seems inprobable that the eggs, from which the larvæ in spring shoots develop, could have been laid in the buds of the previous season, because there are frequently two or more mines on a season's growth, one distal to the other, and each forming a complete and continuous channel of its own. (See Plate VI, fig. 1.) Now, since neither larvæ nor new mines were found in Ribes after the middle of July, it seems necessary to assume that the imagines which emerge during June and July, live through the winter, unless some *live pupæ remain in the ground over winter* so that some imagines would emerge the following spring. Chambers[9] observed such a bitypic life-history in some species of Lithocolletis, another tineid genus, and like phenomena are known to occur in other Lepidoptera. However only empty cocoons were found in the ground during August. A very remote possibility is that a second brood feeds in the cambial cylinder of some species of plants which continue their cambial activity during late summer.

[9] Chambers, V. T. Annual address of V. T. Chambers, esq. *Journ. Cin. Soc. Nat. Hist.* **2**: 89. 1879.

Observations on the mines and streaks.— Eggs were not seen, but, about the middle of May, many small, young larvæ were found in the cambium of young shoots. After progressing 7—20 cm. toward the tip a fairly regular, semicircular turn is made which brings the cambium-miner parallel, and headed opposite to its former course. The distal-turn may be either clockwise or counter clockwise, but the basal-turn is always made in the *same wise* as the distal one, so that a continuous channel results having its pair of long runs more or less parallel and with similar end-turns. (See Plate VI, fig. 1.) By the time a larva arrives at its starting point the meristematic cells about its former mine seem to have proliferated into the channel sufficiently to afford suitable food, because it remines and enlarges its former tunnel; except occasionally one makes what seems to be its second distal-turn a few millimeters short of its first one. It appears that after a larva makes from 2 to 2¼ rounds it emerges to pupate in the ground beneath. The crescent shaped exit-hole was always found nearer the basal than the distal turn of a mine, and generally within one or two centimeters of the former. The exit was sometimes made before but more frequently after the basal-turn had been passed. Often a slight lateral deviation from its former channel was found to have been made by a larva when burrowing its way out, thus recording the direction of its course through the mine. As may be inferred from the above, at the end of a growing season the proximal portion of a channel is always found in the older part of the annual growth, and therefore more deeply buried than the distal part. The mines occur in the wood of both old and young Ribes canes and may be found anywhere from the tip to the ground. However, in *R. nigrum* they are most common in one year old wood while in *R. vulgare* and *R. Grossularia* the current season's growth seems to have them in greater numbers.

The economic relations of the Ribes miner.— It is impossible to state accurately the effects that numerous Opostega-mines have on the different species of Ribes but it seems likely that

they may sometimes be of considerable economic importance, both by direct injury to the plants and by affording entrance to other harmful agencies. When dead side-spurs or withering leaves are found to have channels passing around their bases, death may be attributed to the mines, but when *R. vulgare* canes are found defoliated prematurely during late-summer, and contain one or more of these mines while undefoliated ones are less mined, the conclusion is not so obvious. However, slender branches having one or more mines crossing the transition region of the past year's to the new growth or a mine making its distal-turn just back of the new terminal bud, are no doubt injured by the channels. The transfer of water is probably hindered more or less by these streaks. It has often been noticed that some stunted plants of *R. vulgare* have uncommonly many and closely crowded mines, but of course it can not be said whether they cause the stunting or whether slow growth causes the mines to be so close together. But however detrimental to Ribes plants the mining, as such, may eventually be shown to be, the secondary or indirect effects may also prove of economic importance, as illustrated by the following observations.

Shortly after the larvæ left *R. Grossularia* perhaps 15—50 per ct. of the mined shoots wilted and died, as shown in Plate VII, fig. A. A wilting shoot was always found to have a band of dead bark surrounding it just proximal to the wilting part. When wilting of a tip first becomes noticeable the wood and pith under its dead or dying girdle of bark may be but slightly discolored though it soon dies throughout and turns dark, while its distal portion is still green. Every dead region was found to be about the basal end-turn of a mine, and had a crescent shaped exit-hole of an Opostega larva near its middle, as shown in Plate VII, figure B 3. In many cases salmon-colored, dipterous larvæ, about 3—4 mm. long, were present under the dead bark, but in every case there was a fungus in the discolored wood and pith. (See Plate VII, fig. C. 5.) Since the fungus was found present in every wilting or dying shoot examined, and the salmon-colored larvæ in

only part of them, it seems probable that the fungus may be the cause. However, mycelial inoculations, from pure cultures of the fungus, were negative except in some cases when placed into fresh, sterile wounds. The majority of the wound-inoculations were ineffective, but some produced canker-like discolorations, and about a tenth of them resulted in the typically discolored, dead regions and the dying distal parts. But in every case the holes left by the Opostega larvæ seem to have been the vulnerable points, for neither the dipterous larvæ nor the fungus were found in other shoots. In the currant growing region of the Hudson River valley a destructive fungus disease* is quite common and the causal fungus could not be successfully inoculated except in fresh wounds. But even though the mined canes were generally present in blighting plantations, no definite interrelation was found between them. It seems possible that cultivation about the bushes during the early part of the pupal stage may kill the insects.

DESCRIPTION OF THE RIBES CAMBIUM MINER.

The larva is a long, cylindrical, whitish caterpillar with brown, rib-like thickenings forming a pair of long-ovate loops on each side of its head which are fused along the lateral lines and with their narrowed anterior ends form an irregular, incomplete circle about the mouth-parts. In the later stages the posterior part of the head-skeleton is covered by a forward-protruding fold from the thorax. Each segment has a whorl of bristle-like hairs and every body segment, except the posterior three, has a narrow band of densely set, short spines; the longest hairs are about 0.6 mm. in length and the spines about 0.015 mm. The head and most of the thoracic hairs project cephalad and all others point caudad. In moulting the skin breaks at the posterior thoracic segment and its two parts slip off in opposite directions. Traces of two pairs of thoracic legs are visible in the older specimens, but neither

*A good general description of this disease is given by F. C. Stewart, in Bulletin 167 of this Station, pp. 292–4. (1899.)

hairs, spines nor legs are present in early stages. When devoid of chætopharous appendages the larvæ look suggestively like those of some Diptera, as evidenced by the fact that a specialist on that group, to whom some were submitted, stated that they "evidently belong to the Mycetophilidæ". But on closer examination the mouth parts are found to be those of a caterpillar rather than of a maggot. About the middle of May the larvæ measured from 3.25-11 mm. in length and from 0.15—0.5 mm. in diameter; they were at no time found to exceed 13 mm. in length. The ratio of length to diameter varied from twenty-one to twenty-four; it does not vary as much as Kienitz observed in the larvæ found in Salix, etc.

The cocoon is flatish-ovate, closely woven, creamy to brown in color and measures about 4.5 x 2.5 mm. The imago emerges from the smaller or abdominal end.

The moth was described by Chambers[10] as follows: "This appears to differ from *O. 4-strigella,* Cham., only in the absence of the four costo and dorso apical streaks. The stalk of the antenæ is sordid stramineous; the eye caps, head, palpi, thorax and fore-wings are white. It has the oblique fuscus spot on the dorsal margin of the fore-wings, the fuscus apex and black apical spot. Size as in *4-strigella.*

"The American and English species form a close natural series. The English *salaciella* has no spots on the wings; *albogalleriella* has only the apical spot; *nonstrigella* has the fuscus spot on the dorsal margin, and the fuscus apex in addition to the apical spot; *auritella* (English) in addition has three fuscus streaks in in the cilia; *4-strigella* has four fuscous streaks in the cilia; as also has the English *crepusculella,* but differently placed. There are, however, other minute differences. It is to be hoped that somebody will, one of these days, find an Opostega larva. It is said that one was once found in Europe."

In order that a more complete description of *nonstrigella* may be easily available, the original description and remarks on his

[10] New Species of Tineina. *Journ. Cin. Soc. Nat. Hist.* **3**: 296. 1881.

Opostega quadristrigella[11] are also quoted, and it should be noted that the later species also flies during the early part of July:

"Silvery white; under surface of body, legs and antennæ sordid yellowish. There is a pale fuscous spot on the dorsal margin of the primaries, before the middle, and the extreme apical part of the primaries is very pale golden yellow, with a black spot at the apex. There are in the yellowish apical part two black costal streaks, and one dorsal one, and one transverse streak in the cilia behind the spot; the first costal streak is very oblique, placed before the apical spot, pointing toward but not quite reaching it; the second is perpendicular to the spot; the dorsal streak is oblique and opposite to the first costal one, and both of these are margined narrowly behind with silvery white. Al. ex., three eighths inch.

"A single specimen came to the light at Camp Bee Spring, of the Kentucky geological survey, in Edmondson county, in the early part of July. The eye caps in this species present a singular structure, the scales being arranged in a series of alternate concentric rows; the tip of the primaries are turned up, or rather bent outward."*

Busck[12], in discussing Clemens' type specimens, also makes a few comparative remarks on *O. nonstrigella,* and the moth is enumerated in Dyar's List.[13]

The histological modifications which result from the mining of this Opostega larva are easily recognized in either cross or longitudinal sections of Ribes canes, and though the general configuration of the mines differ much from the type observed in some other woody plants, there are some striking similarities in their histological details. The descriptions and figures of mines in the wood of various trees and shrubs by T. Hartig, Ratzeburg, Kraus, Kienitz and others, under the head of medullary-spots,

[11] *Cin. Quart. Journ. Science* **2**: 106. 1875.

* The writer wishes to thank A. Busck for copying this quotation for him, but especially for so kindly determining the species.

[12] Busck, A. Notes on Brackenridge Clemens' types of Tineina. *Proc. Ent. Soc. Wash.* **5**: 208. 1903.

[13] Dyar, Fernald, Hulst and Busck. A list of North American Lepidoptera and key to the literature of this order of insects. *U. S. Nat. Mus. Bul.* **52**: 547. 1902.

etc., seem fundamentally applicable to modifications found in Ribes. In cross sections brown lines are usually seen bounding a spot on its radial sides but especially on the side toward the pith, showing that regeneration occurs mostly from the cortical tissues. The proliferation of cells into the channels and their subsequent growth are so active that they and the brownish masses of frass and cell-remains are much compressed, so that the new and irregular cells become sharp-angled and straight-walled. They have thickened walls with numerous pits and contain much starch. Figure 1 of Plate VIII gives an idea of the relation of the parts in a cross section of a *Ribes nigrum* shoot.

CAMBIUM MINER OF PRUNUS AND CRATÆGUS.

The hosts infested.— Species of Prunus and Cratægus growing in clumps or straggling thickets along fences, brooks and other obstructions were usually found infested with a tree cambium-miner which appears and mines much like that described and figured by Kienitz (Plate IX, figs. 2, 3, and 5.) *Prunus Mahaleb* and seedlings of *P. avium* grow abundantly in such locations and all of them possessing active cambium during late summer seem always to contain numerous larvæ. *P. serotina, P. virginiana, Cratægus Oxyacantha* and other species of Cratægus when among infested *P. avium* or *P. Mahaleb* plants had the same miner in them. They were also found in *P. Cerasus* and *P. domestica* of some nurseries. The mines and larvæ were present in various sized stems, branches, and shoots of the above hosts from the ground (even underground) up to nearly three meters above.

Description of the mines and comparison with Kientiz's medullary spots.— The configuration of their mines seems the same as that shown in figures cited above, but in most of the hosts the distance between the basal and distal end-turns is usually greater than that given by Kienitz (20–30 cm.). However, in *Prunus Mahaleb* the distance is often only 20—45 cm., while in *P. avium, P. serotina* and *P. virginiana* it is frequently 60—85 cm., approaching more nearly the demensions recorded by Th. Hartig.

But the same pointed end-turns and more or less irregular, meandering course are characteristic and common to the streaks left by both the Prunus cambium-miner and those by Kienitz's Salix and Betula miner. But a mine in a rapidly growing plant often has its returns nearly parallel while those in a slowly growing one generally meander hither and thither, sometimes crossing and recrossing each other. However, the difference between these mines and the shorter and more regular mines of *Opostega nonstrigella* with their semicircular end-turns is very striking.

Description of the Prunus cambium-miner and comparison with Kienitz's miner.— The Prunus cambium-miner is a whitish, filiform, maggot-like larva, devoid of hairs but having each body-segment provided with from one to nine somewhat incomplete girdles of small rectangular plates. The four anterior segments have only one irregular, plate-girdle each; but back of that their number per segment increases and they are grouped into bands of regular radiating circles around the body of the larva. The last segment has a band of nine circles. The plates have a peripheral length of about 5μ, a radial width of about 3μ and are about 0.3μ thick. The dotted lines in Figure 5 and Plate IX, give an idea of the arrangement of the plate-girdles and bands, except that posterior segments of the Prunus miner are shorter and the bands on them wider and therefore closer together. The thorax bulges appreciably instead of having the diameter of the hinder part of the body as represented in the figure cited. The most conspicuous part of the head is a single but maggot-like hook, not two as Kienitz found on his cambium-miner.

The Prunus-miner was always found with one of its lateral sides toward the bark, and in all observed cases end-turns were made toward the dorsal side and most generally counter-clockwise, i. e., the miner usually had its right side toward the bark. The distance mined by a larva, before getting back to its starting point, is so great and its progress so slow that its former mine is overgrown with from one to three millimeters of new wood; remining its former channel, as is done by *Opostega nonstrigella,* would therefore be impossible for this miner.

At the time of their discovery (August 15) the larvæ were from 4—5 mm. long and at the approach of cold weather (November 15) 4.5—5.2 mm. and they were still in the cambial cylinder. They evidently hibernate in their hosts, as is also indicated by the presence, in the early spring wood, of old mines or streaks with tangential diameters about three times that of mines made this autumn. The larvæ seem to have grown but little during the three months they were under observation, and unless they make a remarkably rapid growth during early spring they will not attain the length of 2—3 cm. given by Kienitz for his larvæ. In view of the above noted differences in structure and habit, and since three or four species of Salix also grew in large numbers among infested Prunus plants, and contained neither mines nor larvæ, this seems not to be the organism discussed by Kienitz; though it probably belongs to the same group because in general they seem to have many similarities in both structure and habit.

Imagines may be obtained next summer.— Although the imago of the Prunus cambium-miner will probably be obtained next spring a more detailed study of the life history of this and the Ribes miner is very desirable. The manner and place of oviposition, the number of molts and full details regarding their feeding and mining habits ought to have attention because this is a new or little-known type of miner, and a detailed study may bring out many facts which would prove of value to systematic entomology.

NOTES ON NEW YORK PLANT DISEASES, I.*

F. C. STEWART.

SUMMARY.

This bulletin contains brief notes on various plant diseases and malformations observed in New York during the past ten years. The principal items are as follows: Bitter rot of apples is a rare disease in New York. Crown gall is an unimportant disease of apple trees. Double, and even triple, apples occur occasionally. Apple leaves affected with scab are particularly liable to spray injury. Apple rust (*Gymnosporangium* spp.) is practically unknown to New York fruit growers except in the Hudson valley and on Long Island. The powdery mildew attacking apples in New York is *Podosphaera leucotricha*. It is common in nurseries and sometimes occurs even on bearing trees in the orchard. The Florida San-José-scale fungus has been found on apple trees on Long Island. Veneer tree protectors may seriously injure apple-tree trunks if left on the trees continuously. The period of incubation for *Puccinia asparagi* is probably less than three weeks. On Long Island, string beans have been found attacked by powdery mildew.

The beech and other deciduous trees in the vicinity of Seventh Lake, Adirondack Mountains, are much injured by *Fomes igniarius* which causes heart-rot. *Fomes fomentarius* is exceedingly common in the same region. Sporophores of *F. fomentarius* often change their direction of growth owing to the falling of the trunk on which they are growing. Sometimes, *Fomes pinicola* occurs on beech and maple. *Cercospora beticola* may be transmitted with the seed of sugar beets. *Phyllosticta betae* has been found on leaves of sugar beet at Flint. Begonia leaves are occasionally attacked by powdery mildew and eelworms. *Calyptospora*

*A reprint of Bulletin No. 328.

goeppertiana occurs on species of Vaccinium in New York. Box-tree cuttings which fail to root are covered with *Phoma stictica.* The leaves of red cedar branches attacked by *Gymnosporangium nidus-avis* are like those on young trees; that is to say, the attack of the fungus brings about reversion to the juvenile form. *Sclerotinia fructigena,* in the Monilia stage, kills cherry blossoms and twigs. *Sclerotinia seaveri,* in its conidial stage, kills many leaves and twigs of *Prunus serotina. Exoascus cerasi* occurs occasionally on cultivated cherry trees, particularly on Long Island. The cherry Gov. Wood appears immune to *Podosphæra oxyacanthae. Cylindrosporium padi* may attack the fruit of *Prunus virginiana.* The spore masses of *Pilobolus crystallinus* on chrysanthemum and rose leaves have been misunderstood. *Erysiphe cichoracearum* has been found on a new host — *Coreopsis tinctoria.* Cosmos is attacked by powdery mildew and a serious stem blight caused by *Phomopsis stewartii.* Occasionally, cucumbers in the open are attacked by a powdery mildew. *Uncinula necator* sometimes grows along the mines of *Phyllocnistis vitigenella* on grape leaves. Contrary to the common belief, the mine of this insect is sub-epidermal. *Plasmopara pygmæa* is destructive to hepatica plants. According to Whetzel, the fungus perpetuates itself by a perennial mycelium as well as by oöspores. *Ascochyta parasitica* and *Septoria parasitica* are sometimes associated with *Puccinia malvacearum* on hollyhock leaves in such manner as to indicate that they are parasitic on the Puccinia. *Microsphæra alni* var. *lonicerae,* said by Salmon not to occur in America, has been found in abundance at Geneva on leaves of Tartarian honeysuckle. The English hop mold or mildew, *Sphærotheca humuli,* occurred destructively at Waterville, Middleburgh and several other places in 1910. Some was found at Waterville, also in 1909. The comb-like raggedness of horse chestnut leaves, so common in New York, is caused by late spring frosts. Norway maple leaves show irregular holes due to the same cause. Sometimes large numbers of Norway maple leaves fall in June from the attack of aphids. *Rhytisma acerinum,* although common on *Acer rubrum* and *A. sacchar-*

inum, does not attack *A. platanoides* in New York. *Septoria cucurbitacearum* has been found on mushmelon leaves near Syracuse. *Albugo candidus* has been found on a new host — *Tropaeolum majus*. Oak spangle galls, caused by *Cynips poculum*, strikingly resemble certain Discomycetous fungi. It seems very doubtful if the reddening of young oat leaves, as it occurs in New York, is of bacterial origin as claimed by Manns. A puzzling case of œdema on pear trees was observed in a nursery store-house at Rochester. In a Long Island orchard the leaves and fruit of Kieffer pears have been severely attacked by *Gymnosporangium globosum*. A pear grower of Kendaia has had much trouble from the failure of pear grafts caused by a canker which attacks the cut end of the stock. A new leaf disease of phlox caused by *Cercospora phlogina* has been found at Floral Park. In a nursery at Geneva, trees of the Compass plum were severely injured by the conidial stage of *Sclerotinia fructigena*, which killed the twigs and produced cankers on the trunks of the trees. In all cases, the fungus entered through the blossoms. Adjacent trees of other varieties, not blooming, were uninjured. The Corticium stage of the potato Rhizoctonia has been found on Long Island. Except on Long Island the Rhizoctonia disease of potatoes is not important in New York. There is no relation between the potato Rhizoctonia occurring in Colorado and New York and *Rhizoctonia violacea* which causes root-rot of alfalfa in Europe. Quince rust, *Gymnosporangium clavipes*, was unusually abundant in 1910. *Rhizoctonia* sp. causes damping off and rot of radishes in greenhouses. It has been proven, by means of artificial cultures, that *Leptosphaeria coniothyrium* is the ascogenous form of *Coniothyrium fuckelii*. Spores of *Leptosphaeria coniothyrium* on pieces of dead raspberry canes lying on the ground may retain their viability for four years. *Mycosphaerella rosigena* causes a leaf-spot disease of roses in greenhouses. *Sphaerotheca pannosa* produces perithecia on stems and leaves of roses in the open air, but not in greenhouses. In 1910, a rye field at Geneva was much infested with *Erysiphe graminis*. An undescribed disease, caused

by a species of Glœosporium, has attacked the leaves and berries of snowberry at Geneva. Two cases of powdery mildew on sweet peas were observed. Timothy heads showing proliferous flowers were abundant at Geneva in 1898. In the Station greenhouse tomato plants have shown leaves and shoots growing from flower clusters and leafy shoots growing from leaf-midribs. A new wilt disease of variegated vinca, caused by *Phoma* sp., was observed at Batavia. Wheat has been attacked by *Tilletia foetens, T. tritici* and *Septoria graminum.*

INTRODUCTION.

In the prosecution of Station investigations in plant pathology the members of the Botanical Department have opportunity for making numerous observations on a great variety of plant diseases in various parts of the State. Many of these observations, while too fragmentary for separate publication, are yet worthy of permanent record. Accordingly, we have decided to publish, from time to time, bulletins containing miscellaneous notes on plant diseases. The present bulletin is the first of the series. It is expected that these bulletins will contain, especially, notes on the occurrence, distribution and economic importance of the various diseases of economic plants in the State. For convenience in reference, all notes on the diseases of a particular plant are placed together and the host plants arranged alphabetically by their common names. It will be observed that many important diseases are not even mentioned. No attempt has been made to make a complete list of the plant diseases occurring in the State. Such a list would be useful and it is hoped that the proposed series of bulletins may furnish the data from which, some time, one may be compiled; but this first bulletin contains only such scattered notes as it seems worth while to publish at the present time.

In connection with this work, it is our intention to build up, gradually, a museum and herbarium of specimens representing as fully as may be possible the diseases of New York economic plants. All specimens which may be mounted on herbarium sheets will be preserved in that manner; while those unsuited

to the herbarium will be placed in cases. In the herbarium the arrangement will be by host plants; for example, the various peach diseases will be placed together in the same folder or series of folders. We shall call this the Host Herbarium to distinguish it from the regular Station herbarium. For the purposes of the plant pathologist, such an herbarium has two important features: First, it provides a place for filing specimens of diseases of non-parasitic origin, such as frost injury, and, also, undetermined diseases and those of unknown origin, such as peach yellows; second, it facilitates the comparison of the characters of the various diseases of a given host plant.

The specimens in the Host Herbarium and also those in the Museum will be numbered so that they may be referred to by number. Numerous such references will be found in the present bulletin. This is done in order that other investigators who may wish to examine the specimens upon which our statements are made may have no difficulty in identifying them.

ALFALFA.

Medicago sativa.

The various diseases affecting alfalfa in New York have been discussed in Bulletin No. 305.[1]

DOWNY MILDEW, *Peronospora trifoliorum* De By. In Bulletin 305, page 394, this fungus is reported to have occurred on alfalfa in five different localities in New York. In an alfalfa field on the Station farm it has occurred during four consecutive years — 1907–1910.

In July, 1909, it was more plentiful than at any other time, yet not sufficiently abundant to cause appreciable loss.[2]

YELLOW TOP.[3] A well-marked case of this disease was observed at Fayetteville on September 17, 1909. In an alfalfa field, over

[1] To the list given in that bulletin should be added *Glœosporium medicaginis* E. & K. since reported by Peck (101, p. 21). The number in the parenthesis refers to the bibliography at the end of this bulletin.

[2] Host Herbarium Specimen No. 1.

[3] For a description of yellow top see Bulletin No. 305, p. 403.

the greater part of which the plants were quite normal in color, there was a semi-circular area of about one-fourth acre on which nearly all of the plants were green below and yellow at the top. In this case, the character of the soil seems to have been a factor. The affected area was near one end of the field on a knoll where the soil was somewhat different from that of the remainder of the field.

In the moister season of 1910 the disease did not reappear, indicating that weather conditions, also, have something to do with it.

ROOT-KNOT, *Heterodera radicicola* (Greeff) Müll.[4] In July, 1909, Mr. F. R. Stevens, an agent of the New York State Department of Agriculture, brought to the Station specimens of alfalfa roots affected with nematode root-knot. These specimens were taken in Madison County, but Mr. Stevens reports having seen the trouble in various parts of the State during the summer of 1909.

APPLE.

Pyrus malus.

BITTER ROT, *Glomerella rufomaculans* (Berk.) Spaul. & von Schr. There appears to be a misapprehension concerning the extent of the damage done by the bitter rot fungus in New York.[5] von Schrenk and Spaulding's map showing the distribution of bitter rot in the United States would lead one to believe that the fungus is common and destructive in western New York.[6] Among New York fruit growers, also, this idea is not uncommon. The fact is, bitter rot of apples is rare in New York. It is of no economic importance whatever. The writer has taken the Glœosporium stage (*G. fructigenum*) only once (at Geneva, in October, 1907) on apple fruit[7] and has never known it to attack apple branches in New York.

[4] The occurrence of a nematode root-knot of alfalfa in New York was first reported in Bulletin No. 305, p. 401.
[5] Stewart (142, p. 84).
[6] von Schrenk and Spaulding (121, p. 13).
[7] Host Herbarium Specimen No. 2.

In reporting the results of a fruit-disease survey of western New York made in 1900 we made the following statement:[8] "Bitter rot, *Glœosporium fructigenum,* is reported to have been unusually common." Doubtless this was an error. We have since learned that what New York fruit growers call bitter rot is sometimes pink rot (*Cephalothecium roseum* Cda.) and sometimes the disease described by the writer[9] under the name of "fruit spot" which, according to Brooks,[10] should now be called fruit pit.

On our grapes, bitter rot occurs more frequently,[11] but even on that fruit it is of little economic importance in New York.

CROWN GALL, *Bacterium tumefaciens* Smith & Town. In New York, the so-called crown gall or root gall disease is common on apple trees as well as on several other woody plants.[12] In the mind of the planter the question naturally arises, What effect will the galls have on the future growth of the trees? During twelve years' acquaintance with apple diseases in New York the writer has never seen or known of a well authenticated case in which crown gall has injuriously affected apple trees in the orchard. The results of the following two experiments recently reported by the writer[13] tend to support the view that crown gall, as it affects the apple, is an unimportant disease in New York.[14] "In 1899, C. H. Stuart & Co., Newark N. Y., set out an experimental orchard of 500 trees, mostly Baldwins, all affected with crown gall. The trees have now been set nine years. Under date of January 20, 1908, Mr. Stuart writes as follows: 'The trees to-day show as good a growth as the trees planted the same time and free from crown gall. The bark is smooth, healthy in appearance, and the trees look thrifty and vigorous.' An experiment

8 Stewart et al (152, p. 297).
9 Stewart (140, p. 216).
10 Brooks (15).
11 Southworth (135, p. 171); Lodeman (74, p. 448); Peck (96, p. 111); and Fairchild (34).
12 Bailey (12, p. 367); Stewart et al (152, p. 300).
13 Stewart (143, p. 98).
14 Hedgcock (59, p. 72) who has made an exhaustive study of crown gall states that the effect of crown gall upon apple trees in the orchard has been overrated.

made by the Station bears on this point. In 1901, we planted twenty-two apple trees affected with crown gall, to determine the effect of this disease upon the growth of the trees. The trees were three years old. The galls varied in size from one to two inches in diameter and were located mostly on the tap-root, but in a few cases on lateral roots. Some of the trees had several galls each. We believe the galls were typical of those commonly found on apple trees in New York nurseries. Five of the trees were dug in 1903, five in 1905 and the remainder in 1907. In no instance was there any evidence that the galls had increased in size or number, or that they had been in any way injurious to the trees. Probably apple trees bearing large galls should be rejected, but unaffected trees from the same lot may be planted without fear of bad results."

LEAF SPOT. In a recent discussion of apple leaf spot the writer made the following statements:[15] "Apple leaf spot, a disease which manifests itself in the form of circular, dead, brown spots on the leaves, is common and often destructive in New York apple orchards. For some years it has been known that such leaf-spotting is frequently due to bordeaux injury,[16] but there are also other causes not well understood. Scott and Rorer,[17] who have been making an investigation of apple leaf-spot in the Middle West, find that the disease, as it occurs there, is caused by *Sphæropsis malorum,* the fungus of apple canker and black rot. Concerning the nature of the disease which we have here in the East they say:[18] 'The common apple leaf-spot disease of the eastern states being so similar in every respect, is doubtless caused by the same fungus, although some other fungi may possibly produce similar spots.'

"Certainly, our orchards are full of the canker fungus, and since it has been proven that this fungus readily attacks apple leaves the above conclusion seems warranted. However, there is

[15] Stewart (144).
[16] Stewart and Eustace (150, pp. 225–233); Hedrick (60, p. 133).
[17] Scott and Rorer (123).
[18] Loc. cit. p. 52.

one fact opposed to this view, viz., in New York, spraying often fails to control leaf-spot.[19] Were the disease due to Sphæropsis it should be controllable by spraying here as readily as it is in Virginia and Missouri. We believe that the leaf-spot problem in New York is not yet completely solved."

Mr. F. A. Sirrine, Riverhead, Long Island, informs us that his apple orchard has been sprayed regularly since 1903 without any appreciable diminution of the leaf-spot, except in 1909, when it was considerably less affected than the unsprayed part of the same orchard owned by a neighbor. Each spring Mr. Sirrine's part of the orchard has been sprayed with lime-sulphur on the dormant wood for San José scale. In addition, one to three applications of bordeaux have been made after blooming; but in 1909 the regular application of lime-sulphur was followed with *four* applications of bordeaux — one before blooming and three after blooming.

In this connection it is worthy of note that *Sphæropsis malorum* rarely fruits on living apple leaves in New York.[20]

MYXOSPORIUM CANKER, *Myxosporium corticolum* Edgerton. This is the bark disease previously described by us under the name Macrophoma canker.[21] Following Paddock[22] we referred the associated fungus to *Macrophoma malorum* (Berk.) Berl. & Vogl., but Edgerton[23] has shown that it properly belongs in the genus Myxosporium and has described it under the name *Myxosporium corticolum*. He uses the common name bark canker. We think Myxosporium canker a better name. On the subject of the parasitism of the fungus we have nothing to add to previous publications. *Myxosporium corticolum* occurs also on the dead bark of pear trees affected with body blight.

DOUBLE AND TRIPLE FRUITS: SYNCARPY. In November, 1906, Mr. J. B. Anderson, a Geneva fruit grower, brought us a double apple of the Baldwin variety. The two parts were about equal

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19 Stewart (139, p. 455); Stewart and Eustace (150, p. 230).

20 The occurrence of *Sphæropsis malorum* on apple leaves in New York has been reported by Peck (94, p. 76) and Stewart et al (152, p. 298). It has been collected, also, by Prof. H. H. Whetzel at McLean, N. Y., June 30, 1906.

21 Stewart et al (152, p. 298).

22 Paddock (85, p. 203 and 86, p. 211).

23 Edgerton (31).

in size (slightly under average size for the variety), they had a common stem, were well formed, and their core axes lay at right angles with the stem. Their general appearance was that of two apples slightly grown together at their stem ends.[24]

At a meeting of the Western New York Horticultural Society in January, 1908, a gentleman showed us a triple apple of the Russet variety.

In January, 1910, Mr. W. H. Alderman, Assistant Horticulturist, showed the writer a double apple, variety Moyer, grown on the Station grounds. In this specimen, the two fruits, although slightly unequal in size, were grown together so closely as to resemble a single apple somewhat flattened and with a groove extending down either side. The stem, which was about an inch long, was slightly flattened as if formed by the union of two stems. The core axes lay nearly parallel and at the tip of the fruit here were two separate calices about 20 mm. apart. (Plate X.)

The above are the only specimens coming under our personal observation, but it is said that double apples are not rare and triple apples, also, are occasionally found.

Masters[25] has described and figured double apples and mentions a figure of a triple apple by Schlotterbec. In the *Country Gentleman* for November 28, 1907, page 1123, there is a figure of a double apple which must have been very much like the Anderson specimen. In a later issue of the same paper[26] the horticultural editor writes as follows:

"Recent notes on siamism in apples, said by some authorities never or rarely to occur, have brought us a number of specimens, the latest being two pairs from Mr. George Beaumont of New Haven County, Conn., who says the tree produces a lot of these monstrosities annually, this year 'half a bushel' of them."

Such doubling of fruit is known as syncarpy. It is teratological rather than pathological. According to Sorauer,[27] double

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[24] Museum Specimen No. 132.
[25] Masters (80, pp. 47, 48).
[26] *Country Gentleman* **73**: 178. Albany, N. Y. 20 F. 1908.
[27] Sorauer (134, p. 376); cfr. also, Frank (40, 3:338).

fruits originate by the fusion of two separate lateral blossom primordia (blossom buds).

SCAB, *Venturia inæqualis* (Cke.) Aderh. Early in June, 1909, we were informed that an unknown trouble had appeared in some of the apple orchards in the vicinity of Medina. Upon making a visit to the worst affected orchard it was found that the trouble was simply a bad case of apple scab combined with spray injury. The Baldwins were more affected than the Greenings, and the Russets least of all. There had been an early outbreak of scab, and as no spraying was done before blooming the fungus spread so rapidly that by the time the blossoms had fallen most of the leaves were more or less affected. About this time the orchard was sprayed with a mixture consisting of six pounds of copper sulphate, twenty pounds lime, six pounds of arsenate of lead, one-fourth pound white arsenic (boiled with sal soda), and one hundred gallons of water. Soon after spraying much of the foliage turned brown and dried up. It was plain that spraying was largely responsible for the injury. Close examination revealed the interesting fact that the leaves most affected with scab were the ones most injured by the spray. In fact, the severity of the spray injury seemed to be directly proportional to the amount of scab on the leaves. However, there was some spray injury on leaves apparently free from scab. The explanation of the greater susceptibility of scab-infested leaves to spray injury seems to be as follows: The scab fungus ruptures the cuticle (the protective covering of the leaf) thereby permitting the soluble copper and arsenic compounds in the spray mixture to be readily absorbed by the cells of the leaf.

A similar conclusion was reached by Mr. E. Wallace, who examined the orchard about the time of our own observations.[28]

Observations made at Webster in the season of 1910 lead us to believe that scab-infested apple leaves are particularly susceptible, likewise, to injury from lime-sulphur spray. It seems probable that some of the mysterious cases of lime-sulphur injury to foliage may be explained in this way.

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[28] Reported by Whetzel (163, p. 20).

It appears that many fruit growers who are thoroughly acquainted with scab as it occurs on apple fruit do not know it on the leaves.

RUST, *Gymnosporangium macropus* Lk.[29] Although the red cedar, *Juniperus virginiana*, which is the host of the telial stage of this fungus, is quite common in many localities in the State, the æcial stage (*Rœstelia pyrata*) is rarely injurious to apples here. It is only on Long Island and a few places in the Hudson valley that the fungus has any economic importance. To apple growers in western New York, rust is practically unknown. We saw a little at Dresden in 1900[30] and at Geneva in 1908 and 1910. Even in the Hudson valley where red cedars are very plentiful the apple rust is but little known to fruit growers. In 1899 we found "cedar apples" quite commonly in Ulster and Rockland counties, but no Rœstelia that year.[31] The only case of apple Rœstelia coming to our notice in 1901 occurred at Highland. In 1902, specimens were received from several localities in the Hudson valley. In 1906, specimens were received from Hudson, together with the report that it occurred in several orchards there. In 1907, a report of an orchard badly infested came from Crown Point on Lake Champlain.[32] In 1909, and again in 1910, a young orchard of the varieties Wealthy and Jonathan, at Milton, was slightly affected.[33] In this case the infection must have come from a considerable distance. There were no red cedars in the immediate vicinity of the orchard. In 1910, specimens were received from correspondents at Hoosick Falls and Mount Kisco, both of whom stated that the disease was new to them. On Long Island, the fungus was infrequent in 1895.[34] Specimens of Rœstelia on leaves of wild apple were collected at Jamesport in 1896[35], and at Cutchogue in 1900.

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[29] Some of the apple Rœsteliæ mentioned here may be the æcia of *Gymnosporangium globosum* Farl. since this species occurs in the State (See p. 376 and Pammel 87, p. 11); but *G. macropus* is much the more abundant.

[30] Stewart et al (152, p. 302).

[31] Stewart and Blodgett (147, p. 285).

[32] Host Herbarium Specimen No. 3.

[33] Host Herbarium Specimen No. 4.

[34] Stewart and Carver (148, p. 544).

[35] Host Herbarium Specimen No. 5.

Since 1902, we have had under observation an apple orchard on the farm of F. A. Sirrine, near Riverhead, Long Island. This orchard is surrounded on three sides by thickets of red cedar. In 1902, the swelling of the "cedar apples" on the adjacent red cedars occurred on May 28th. Some trees were literally loaded down with them. But, unfortunately, we have no record of the prevalence of rust on the apple leaves that season. The spring of 1903 was very dry. At Riverhead there was no precipitation of any importance between April 16th and June 8th. As a consequence, there was no opportunity for the infection of apple leaves until June 8th and 9th, on which dates there were heavy showers, and the "cedar apples" became swollen into yellowish, gelatinous masses of unusually large size. Very little rust occurred on the apple leaves that year. On June 1, 1904, Rœstelia spots were already appearing on the apple leaves in this orchard. The rust-resistance of the Baldwin is shown by the fact that in August, 1904, a Baldwin tree in this orchard was entirely free from Rœstelia, while adjacent Russet trees on the north and west were yellow with it. In 1905, there was very little rust here. In December, 1907, Mr. Sirrine brought us a Ben Davis apple from his orchard showing Rœstelia in the calyx cavity. In the autumn of 1909, examples of Rœstelia on apple fruit were plentiful, particularly on the varieties Ben Davis and Rome.[36] (Also, we saw it on fruit of wild apples at Cutchogue.) In 1910, there was only a little rust on the leaves and on an occasional fruit of Ben Davis.

Another orchard, set by Mr. Sirrine in 1905, furnished (in 1909) some data on the relative susceptibility of different varieties. Although these young trees were sprayed twice with bordeaux — June 1st and about two weeks later — some varieties showed much rust.[37] Wealthy, Boiken and Rome were very rusty;

[36] Museum Specimen No. 133.

[37] On June 3, 1909, the writer observed that the "cedar applies" of *G. macropus* in the vicinity of this orchard were fully expanded by the rains occurring at that time. Whether there had been an earlier opportunity for infection we do not know.

Hubbardston and Sutton were slightly affected; while McIntosh, Yellow Transparent, Gravenstein, Red Astrachan and Oldenburg were nearly or quite free from rust. It may be added that Mr. Sirrine has usually had little success in controlling rust in his bearing orchard by the method of spraying described on page 313. However, he states that, in 1910, trees given two applications of bordeaux (3–3–50 formula) showed only one-tenth as much rust as the unsprayed portion of the orchard. The first application was made on April 30th, as the blossoms were commencing to open, the second on May 21st. Very small, yellow rust spots were plentiful on the leaves of unsprayed trees on June 15th.

Variegated foliage. In 1896, we observed, at Jamesport, Long Island, a bearing apple tree on which practically all of the leaves were beautifully variegated with yellow. The following year, also, all of the foliage on this tree was again variegated. But an adjacent tree which showed variegation on one of its branches in 1896 was entirely free from variegation in 1897. A third tree had variegation on two branches in 1897.[38] In 1907, specimens of variegated apple leaves were brought to us by a Wayne county fruit grower who said that only a few branches in the tree were affected.[39] On an apple tree in the orchard of H. L. Bulkley, Brockport, N. Y., certain branches show variegated leaves year after year. In 1910, a row of two-year-old apple trees in a nursery at Geneva had more or less variegated foliage on almost every tree. The variety was Boskoop and the length of the row about thirty rods. In most cases only a few leaves in the lower part of the tree were variegated.

Powdery mildew, *Podosphæra leucotricha* (E. & E.) Salm.[40] Peck[41] has reported this fungus from Clyde, N. Y., and several outbreaks of it have come to our attention. In one case it occurred in one of the Station greenhouses on some young Bald-

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[38] Host Herbarium Specimen No. 6.
[39] Host Herbarium Specimen No. 7.
[40] Salmon (116, p. 40).
[41] Peck (100, p. 19).

win apple trees used by the Station Horticulturist in his investigations on bordeaux injury. It first appeared about March 1, 1907, and by March 26th every tree in the greenhouse was more or less affected, some of them being quite severely injured. The mildew shows first on the upper surface of the leaf and its coming is heralded by the appearance of spots of lighter green color. As the mildew spreads the affected leaves appear as if dusted with flour. The petioles, young stems and under surface of the leaves also became affected, but the most luxuriant growth was invariably on the upper surface. By March 26th there were mature perithecia seated on patches of brown, felted mycelium on the young stems and petioles.[42] No perithecia were observed on the leaf blades. Specimens showing perithecia in abundance were taken on May 1st.

In another case the mildew was found in October, 1909, at Geneva, on sprouts growing around the stumps of some apple trees which had been cut down the previous spring. The leaves were white with mildew on the upper surface and there was also a little on the under surface. Perithecia were numerous, but they seemed to be confined almost entirely to the patches of brown mycelium on the stems near the tips of the shoots.[43]

During the season of 1910 powdery mildew was common on young apple trees in New York nurseries. It also occurred frequently in young orchards and occasionally in bearing orchards. Mr. Parrott, the Station Entomologist, reports having seen bearing orchards at Carlton Station and Brockport affected by powdery mildew in May. At Brockport, the ends of branches on trees thirty-six years old were attacked. The writer has seen specimens taken from this orchard and found perithecia of *P. leucotricha* on them.[44]

In a Geneva nursery, perithecia of *P. leucotricha* began to appear as early as June 30th. Many varieties were more or less affected. The varieties Chenango and Black Ben Davis appeared

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[42] Host Herbarium Specimen No. 8.
[43] Host Herbarium Specimen No. 9.
[44] Host Herbarium Specimen No. 10.

particularly susceptible. In September, the leaves at the tips of the shoots were dwarfed and whitened with mildew. Often they were curled and brown on the margins. Many of the affected leaves had fallen prematurely. The twigs, also, were covered with mildew, some of which was white and some brown. Large numbers of perithecia were imbedded in the felt-like patches of brown hyphæ on the twigs and petioles and occasionally on the leaf-midribs, but none were seen on the thin parts of the leaves. The growth of the trees had been checked somewhat. Some were considerably injured.

We are under obligations to Mr. V. B. Stewart, of the New York College of Agriculture, for a quantity of fine specimens of *P. leucotricha* collected in a nursery near Orleans, N. Y., where he found it very abundant in the summer and autumn of 1910.

In reporting the results of some experiments on the treatment of the diseases of nursery stock in western New York in 1891 and 1892, Fairchild mentioned an apple powdery mildew which he doubtfully referred to *Podosphæra oxyacanthæ* (DC.) Winter.[45] However, there are good reasons for believing that it was, in reality, *P. leucotricha*. In the Station herbarium there is a specimen[46] of powdery mildew on apple labeled *Podosphæra oxyacanthæ* (DC.) DeBy. The envelope containing it bears the following note in the handwriting of Prof. S. A. Beach: "On stems and leaves of *Pirus malus* L. nursery seedlings. In some seasons it does much damage to nurseries in vicinity of Geneva as well as elsewhere throughout the Northern States. Col. by D. G. Fairchild and S. A. Beach Oct. 21, 1892 near State Exper. Station, Geneva, N. Y. Showing perithecia." Probably this specimen represents the powdery mildew mentioned by Fairchild. Upon examination it is found to be *Podosphæra leucotricha* (E. & E.) Salm. The perithecia occur only in brown patches of mycelium on the stems and petioles and have the two kinds of unbranched appendages characteristic of *P. leucotricha*.[47]

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[45] Fairchild (35, p. 256); also, N. Y. (State) Sta. Rpt. 11:663. 1893.
[46] Host Herbarium Specimen No. 11.
[47] Salmon (116, Pl. 7, figs. 119, 120).

The occurrence of *Podosphæra oxyacanthæ* on nursery apple trees in New York has also been reported by the writer.[48] In this case, likewise, there is some doubt as to the identity of the fungus. No specimens were preserved, but in the original notes (still in our possession) it is distinctly stated that no perithecia were observed. Such being the case it was impossible to determine the species accurately. It seems that the determination was based on the fact that the fungus grew more abundantly on the under than on the upper surface of the leaves. It also occurred on the stems. The observations were made August 8, 1910.

Of course it is possible that *P. oxyacanthæ* sometimes occurs on the apple in New York, but no authentic instance is known to us. All of the specimens (showing perithecia) which have come to our attention belong to *P. leucotricha.*

FUNGUS PARASITE OF SAN JOSÉ SCALE, *Sphærostilbe coccophila* Tul. This is a fungus which lives parasitically on various species of scale insects. It is quite widely distributed throughout the warmer regions of the world. In 1897, Rolfs[49] called attention to its occurrence on the San José scale in Florida where it seemed to be an important factor in keeping the insect in check. He showed how the fungus may be cultivated artificially and used to combat the scale. In 1908, Fawcett[50] stated that there had been found an effective method of distributing the fungus which has saved thousands of dollars to the peach and orange growers of Florida. Although the fungus is reported as occurring naturally as far north as Elberon, N. J.,[51] attempts to introduce it into the Northern States and Canada have been unsuccessful.[52] Even in Alabama and Georgia where the fungus grows abundantly on the oak scale, *Chrysomphalus obscurus,* it is inefficient for the control of San José scale.[53] It appears that Florida is the only

48 Stewart et al (152, p. 302).
49 Rolfs (111, 112 and 113).
50 Fawcett (38, p. 28).
51 Smith (130, p. 567).
52 Smith (128, pp. 470–479); 129, p. 445; 130, p. 567; Forbes (39, pp. 270–280); Webster (161, p. 198); Craig (23, p. 119).
53 Earle (30, p. 175); Lewis (71).

State in the Union in which the fungus is of recognized value in the control of the scale.

Such being the case, it is an interesting fact that in October, 1909, we found this fungus very abundant in a scale-infested apple orchard near Hicksville, Long Island. The orchard has been infested with San José scale about ten years, during which time it has been neither pruned nor sprayed. Although all of the trees are covered with the scale only a few have died. The majority are still in fair condition. Given proper care, the orchard could be made to produce fair crops of apples still, notwithstanding the fact that the scale has had its own way with the trees for ten years. What part the fungus has had in holding the scale in check in this orchard can only be conjectured, since nothing is known of its occurrence there prior to 1909. It can only be said that in October, 1909, the fungus was epidemic, growing on the bodies of the scale insects wherever there were any to be found in every living tree in the orchard. The fungus was readily discernible to the unaided eye as minute pink cushions, knobs or conical projections scattered over the scale-infested bark. Whether it occurs in other scale-infested orchards on Long Island we do not know. No search for it has been made. Perhaps, on Long Island, the fungus may be of some assistance in checking the ravages of the scale in neglected orchards. In other parts of New York it is probable that climatic conditions are unsuited to it.[54] However, we have seen traces of the fungus on scale-infested currant canes in the Hudson valley and also at Geneva.

It should be understood that probably the fungus cannot be used, successfully, in orchards sprayed with lime-sulphur since it is likely that lime-sulphur will kill the fungus. For this reason it can be of little use to commercial orchardists in this State. In scale-infested orchards spraying with lime-sulphur cannot be omitted.

[54] A moist climate is considered favorable to the development of the fungus, but the summer of 1909 was a very dry one on Long Island.

A brief account of the above observations published[55] in November, 1909, is the earliest record of the occurrence of the scale fungus in New York. No perithecia were found — only the conidial form known as *Microcera coccophila* Desm.

TRUNK INJURY. In May, 1910, some observations were made on an interesting disease of apple tree trunks at Le Roy. The orchard in which the trouble occurred contained 450 moderately thrifty trees, nine and ten years old, growing in timothy sod. All of the trees had been topworked; 300 of them had Walbridge stocks, while the remainder had Northern Spy stocks. In the fall of 1906, veneer tree protectors, twenty inches high, were placed around the trunks of all the trees to protect them from mice. These "protectors" consisted of thin sheets of wood which were wrapped loosely about the bases of the tree trunks and held in place by wire bands. They were left on the trees continuously until the spring of 1910. It was then discovered that about sixty of the trees on Walbridge stocks were more or less injured. On the portion of the trunk covered by the "protector" the bark was rough and showed numerous dead spots of various sizes from mere specks to spots as large as a man's hand. The smaller spots did not extend through the bark, but on many of the larger ones the bark was dead all the way through and the sap-wood was bluish black. Occasionally, the diseased spots occurred well up on the trunk, even to the crotch, but the great majority of them were within twenty inches of the ground. Several of the trees were practically ruined, and a number of others were considerably injured. The owner first noticed a few of the trees affected in the spring of 1908, and a few more in 1909; but the greater part of the trouble first appeared in the spring of 1910.

It was plain to be seen that the veneer tree protectors were, in some way, responsible, but the exact manner in which the trouble had been brought about was not clear. The canker fungus, *Sphæropsis malorum*, may have been a factor since some of the larger spots showed pycnidia of this fungus. The bark under the "protectors" was thickly covered with the oyster-shell

55 Stewart (146).

scale, *Lepidosaphes ulmi* Linn., which may, also, have been a factor. The owner states that in April and again in the forepart of July there was a copious exudation of sap from the diseased spots. This might lead to the suspicion that the fire-blight organism, *Bacillus amylovorus,* had something to do with it, but the writer is confident that such was not the case. There was no other evidence of fire blight in the orchard.

The trouble was confined to the trees having Walbridge stocks. Those with Northern Spy stocks were entirely free from it. Since all the conditions surrounding the two kinds of stocks were alike, it seems fair to conclude that Walbridge is the more susceptible to such injury. As remedial measures, the orchard was plowed and the tree trunks painted with a mixture of lime, copper sulphate and linseed oil after they had first been well scraped with wire cloth and all dead bark removed from the larger cankers.

In September the owner reported that several apparently new cases had appeared during the summer. He thinks that the mixture of lime, copper sulphate and linseed oil had little influence on the disease, but that cutting out the spots of diseased bark checked it somewhat.

ASPARAGUS.

Asparagus officinalis.

RUST, *Puccinia asparagi* DC. In New York, asparagus rust has been destructive nearly every season since its first appearance on Long Island in 1896.[56] On Long Island, especially, the loss has been heavy. Sirrine's experiments,[57] published in 1900, showed plainly that rust may be largely prevented and the yield and quality of asparagus much increased by spraying with resin bordeaux mixture. Since 1903, Mr. Sirrine has grown asparagus on his own farm at Riverhead and practiced regular spraying. He is thoroughly convinced that spraying is profitable. While

[56] Stewart (139, p. 458).
[57] Sirrine (127).

unable to control rust, entirely, he has succeeded in preventing it from causing serious damage. Also, he has reached the conclusion that the addition of resin to the bordeaux does not increase its efficiency enough to warrant using it. The resin seriously interferes with the operation of the spray pump. He now uses ordinary bordeaux mixture.

Mr. Sirrine informs us that Long Island asparagus growers do not spray or employ any other special treatment for rust. They now plant chiefly the varieties which have been found most rust-resistant, namely, Palmetto and Argenteuil; but these varieties are not nearly so resistant as they were formerly supposed to be.

Sirrine states[58] that, on Long Island, the æcial stage of *Puccinia asparagi* appears about June 1st. June 4, 1901, we found æcia abundant in a two-year-old asparagus bed at Poughkeepsie. They occurred only on the lower ten or twelve inches of the stalk.[59] June 2, 1909, we found uredo sori on volunteer asparagus plants at Riverhead. Mr. Sirrine is positive that he saw some uredo sori as early as May 15th — the earliest he ever saw them. In this case the æcia must have appeared about May 1st. In 1910, æcia were observed at Riverhead by Mr. Sirrine on May 5th.

Halsted[60] has recorded an observation which led him to express the opinion that the time required for the rust to appear in pustules upon the asparagus is about three weeks. In 1898, the writer made a similar observation indicating that the period of incubation is under, rather than over, three weeks. On August 14th a rusted asparagus bed at Mattituck was mown off close to the ground. Twenty-four days later (September 7th) we found many plants of the new growth showing uredo sori; and Mr. F. H. Blodgett, who examined the plants one day earlier, informed us that he, also, observed some uredo sori. Taking into consideration the fact that the plants required some time to start new shoots, and that the sori probably appeared some time before the

[58] Loc. cit. p. 236.
[59] This habit has been observed also by Clinton (21, p. 314).
[60] Halsted (48, p. 347).

observations were made, it appears that the actual period of incubation must have been less than three weeks. It is probable that the infection came from uredospores.

BEAN.

Phaseolus vulgaris.

Powdery mildew, *Erysiphe polygoni* DC.? In October, 1909, some string beans (*Phaseolus vulgaris*) in a garden at Cutchogue, Long Island, were found affected with powdery mildew. At the time the observations were made most of the bean leaves were already dead, from frost, but it was evident that the mildew had been abundant. The leaves (both surfaces) and leaf petioles were thickly covered with the conidial form of a powdery mildew.[61] As no perithecia were found the identity of the fungus must remain in doubt. It appears that beans are not often attacked by powdery mildew. This is the first time the writer has seen it, and so far as we can learn, it has not been recorded previously as occurring in New York. Galloway[62] has reported powdery mildew on beans at St. George, Bermuda. In this case the fungus was doubtfully referred to *Erysiphe communis* Lév. (= *E. polygoni* DC.)[63] Prillieux[64] gives the "haricot" (*Phaseolus vulgaris*) as one of the hosts of *Erysiphe communis*.

Increased number of cotyledons. Recently, we saw ten common white beans having three cotyledons (seed leaves) each, and another having four cotyledons. There can be no doubt about the accuracy of the observation in either case.

BEECH.

Fagus grandifolia.

White heart-rot, *Fomes igniarius* (L.) Gillet. During August, 1909, the writer, in company with Dr. B. M. Duggar

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[61] Host Herbarium Specimen No. 12.
[62] Galloway (45).
[63] Salmon (116, p. 182).
[64] Prillieux (105, 2:16).

and Prof. H. H. Whetzel, made some observations on the heart-rot of beech trees in the vicinity of Seventh Lake in the Adirondack Mountains, where the beech is one of the principal hard-wood timber trees. This disease has been so fully treated by Atkinson[65] and von Schrenk and Spaulding[66] that little need be added. Peck[67] and Murrill,[68] also, have reported its occurrence in New York. However, it may be worth noting that this heart-rot is very common and destructive to the beech trees around Seventh Lake; also, that the conditions found there are quite in accord with von Schrenk and Spaulding's statement that, "In New York and New England the beech has been found to be the most common host of this fungus." While the fungus was most commonly found on beech[69] it was observed, also, frequently on striped maple (*Acer pennsylvanicum*),[70] occasionally on sugar maple (*A. saccharum*)[71] and yellow birch (*Betula lutea*) and once on aspen (*Populus tremuloides*).[72] One of the largest sporophores (on beech) was 3 dm. (12 inches) wide, 2 dm. (8 inches) thick at the base and, judging by the number of layers of pores, about 15 years of age.[73] A considerably larger sporophore, probably 4.5 dm. (18 inches) wide, was seen but not measured. The sporophores are usually found on standing trees (commonly on living ones) and are few in number — usually one to four.

TINDER-FUNGUS ROT, *Fomes fomentarius* (L.) Gill. With one exception (*Fomes applanatus*), *Fomes fomentarius* is probably the most common representative of the Polyporaceæ growing on deciduous trees in the vicinity of Seventh Lake. It occurs on prostrate or standing dead trunks of beech, yellow birch and hard maple and occasionally, also, on living trees of the same species. On individual trunks the number of sporophores is often quite

[65] Atkinson (10, pp. 214–222).
[66] von Schrenk and Spaulding (122, pp. 25–37).
[67] Peck (88, p. 83; 91, p. 36; 98, p. 218).
[68] Murrill (82, p. 111).
[69] Museum Specimen No. 80.
[70] Museum Specimen No. 11.
[71] Museum Specimen No. 36.
[72] Museum Specimen No. 54.
[73] Museum Specimen No. 5.

large — twenty to forty or more. Like many other fungi of this family the sporophores of *Fomes fomentarius* have a decided tendency to grow toward the earth (positive geotropism). Invariably, they grow with the hymenium turned toward the earth. This habit was interestingly shown by a colony of sporophores on a fallen beech tree near Limekiln Lake observed by the writer in August, 1909. (Plate XI.) The tree, which was about two feet in diameter, had been blown over some time during 1908, probably; yet it was in full leaf and, apparently, very much alive. On one side of the lower portion of the trunk there were more than forty sporophores of *Fomes fomentarius* scattered over an area about ten feet long by two feet wide. The majority of the sporophores had been formed before the tree fell, and, in these, the hymenium faced the base of the tree; while in others, formed after the tree fell, the hymenium faced the earth. There were, also, a few sporophores which were twisted in consequence of having changed their direction of growth at the time the tree fell.[74] (Plate XII, fig. 2.)[75]

Recently, von Schrenk and Spaulding[76] have questioned the parasitism of *Fomes fomentarius.* In the instance cited above it seems to us that the evidence is in favor of its being parasitic. On the diseased portion of the trunk the dead bark adhered closely and there were no wounds or exposed wood. Neither was there evidence of the presence of any other fungus which might have killed the bark.

Several good examples of twisted sporophores were collected near Seventh Lake in 1910. Some were on beech and others on hard maple. One of these, on beech, is shown in Plate XII, fig. 1. In this case the tree fell in such manner that the sporophore was on the upper side of the prostrate trunk. With the renewal of growth there appeared on the old sporophore three new sporo-

[74] Similar cases in *Fomes applanatus* and *Dædalea ambigua* have been described and illustrated by Atkinson (9, pp. 15–17).

[75] Museum Specimen No. 15.

[76] von Schrenk and Spaulding (122, p. 49).

phores (two of them partially grown together) with hymenial surfaces in a plane at right angles to that of the parent sporophore.[77]

The largest sporophore we have found was on a standing dead trunk of hard maple. It was 1.5 dm. (six inches) wide on the attached side and 3.4 dm. (13.5 inches) in circumference.[78]

Fomes pinicola Fr. The usual hosts of *F. pinicola* are coniferous trees, but it occurs occasionally also on beech and other deciduous trees.[79] At Seventh Lake we have observed it on dead trunks of beech[80] and sugar maple.[81] All of the sporophores lacked the reddish marginal zone usually found in specimens on coniferous trees. This has been noted previously by Peck.[82]

BEET.
Beta vulgaris.

CERCOSPORA LEAF-SPOT, *Cercospora beticola* Sacc. In New York, this is usually a very common and, often, destructive disease of sugar beets,[83] but it was rare in 1909. On October 6, 1909, several large fields of sugar beets in the vicinity of Geneva were carefully examined and Cercospora found to be so rare that a long search was necessary to find a single spot caused by it.

During several years past this Station has coöperated with the United States Department of Agriculture in some investigations on the improvement of the sugar beet. In the experiment conducted on the Station farm in 1902, there was an instructive outbreak of *Cercospora beticola.* The experiment field contained twelve long, narrow plats (11.7 x 467 feet) each having an area of one-eighth acre. The various plats were planted with seed grown in different parts of the United States, France and Germany, as follows:

Plat 1. Klein-Wanzleben. Grown in Germany.
Plat 2. Klein-Wanzleben. Grown in Germany.

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77 Museum Specimen No. 115.
78 Museum Specimen No. 6.
79 Atkinson (10, p. 227); von Schrenk (120, p. 24); Peck (99, p. 169); Murrill (83, p. 228); Romell (114).
80 Museum Specimen No. 19.
81 Museum Specimen No. 43.
82 Peck (99, p. 169).
83 Duggar (27, p. 352).

Plat 3. Dippe Elite Klein-Wanzleben. From Germany.
Plat 4. Vilmorin. French. Very rich in sugar.
Plat 5. Klein-Wanzleben. Utah grown.
Plat 6. Klein-Wanzleben. California grown.
Plat 7. Strand's Klein-Wanzleben. From Germany.
Plat 8. Hoening Improved Klein-Wanzleben. Germany.
Plat 9. Jaensch's Victrix.
Plat 10. Klein-Wanzleben. Michigan grown.
Plat 11. Klein-Wanzleben. Grown in Washington State.
Plat 12. Klein-Wanzleben. Washington grown.

Early in August, 1902, *Cercospora beticola* began to appear on Plat 10. By August 21 this plat was badly diseased throughout its entire length while only traces of the disease were to be found on any of the other plats excepting the two adjacent ones (Nos. 9 and 11) on which there was a light sprinkling of spots. A month later the disease had spread over the entire field, but not much damage had been done except on Plat 10, which was now conspicuous because of a second growth of dark green leaves, practically all of the early leaves having been destroyed by the Cercospora.

The circumstances attending this outbreak indicate plainly that the disease was transmitted with the seed used on Plat 10. The probability of *Cercospora beticola* being transmitted with the seed was shown some years ago by Frank who pointed out that the fungus attacks the seed-balls as well as other parts of seed-bearing plants.[84]

Phyllosticta leaf-spot, *Phyllosticta betæ* Oud.[85] Phyllosticta disease of beets in this State has come to our attention but once, viz., at Flint, in August, 1900. In a field of sugar beets there were a few small areas on which the lower leaves of the plants showed circular, dead brown spots 5 to 10 mm. in diameter.[86] The upper surface of the spots was dotted with black pycnidia visible to the unaided eye. The spores were hyaline,

[84] Frank (41).
[85] Identified by C. H. Peck.
[86] Host Herbarium Specimen No. 13.

non-septate, 3-4 x 4-6 μ. It was not observed that the disease affected the roots.

This is probably the same as the Phyllosticta leaf-spot and root-rot of beets described by Halsted in New Jersey.[87]

BEGONIA.

Begonia sp.

POWDERY MILDEW. February 3, 1900, the writer observed a powdery mildew on begonias in a greenhouse at Queens, N. Y. It was common on the stems but did not attack the leaves. As no perithecia were found, the species could not be determined. We have found no published record of the occurrence of powdery mildew on begonia.

EELWORMS IN THE LEAVES. In December, 1899, we received from Queens, N. Y., specimens of begonia leaves showing large, irregular, dead, brown areas. Microscopic examination of the diseased tissue revealed the presence of numerous eelworms which were probably the cause of the disease. The species of the eelworm was not determined. Halsted[88] has reported a nematode disease of begonia leaves in New Jersey. In England, a similar leaf disease of begonias is caused by *Aphelenchus olesistus* Ritzema-Bos.[89]

BLACKBERRY.

Rubus spp.

ORANGE RUST, *Gymnoconia peckiana* (Howe) Dug. In the æcial stage, known as *Cæoma nitens* Schw., this fungus is a well known destructive parasite of blackberries and black raspberries in New York; but the telial stage is practically unknown except to mycologists. Although not rare, it is much less common than the æcial stage and also quite inconspicuous. In August, 1909, Dr. Duggar and the writer found the telial stage exceedingly abundant on the foliage of wild blackberries in the vicinity of Seventh Lake and Limekiln Lake in the Adirondack Mountains. Viewed from the

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[87] Halsted (53, pp. 338–340).
[88] Halsted (49, p. 310).
[89] Anonymous (2); Ritzema-Bos (108).

upper surface the affected leaves appeared normal except for their yellowish color. On the under surface they were thickly dotted with small black sori. Apparently, the growth of the plants was but slightly affected.[90]

FASCIATION. A fasciated cane of cultivated blackberry[91] was found at Charlotte, N. Y., June 2, 1903. It was affected with orange rust and was entirely free from prickles, as is frequently the case with rusted canes.[92]

RUST, *Kuehneola albida* (Kühn) Magn. The pale, yellowish-white color of the telial sori distinguishes this from the other rusts infesting blackberries. Apparently, it is not common in New York. In September, 1901, we found the telial stage occurring sparingly on the leaves of cultivated blackberries at Milton and Highland. Dr. D. Reddick informs us that he found it abundant on wild blackberries at Ithaca in September, 1906.

BLUEBERRY, SWAMP
Vaccinium corymbosum.

RUST, *Calytospora gœppertiana* Kühn. The Station museum contains an exceptionally fine large specimen of the witches' broom deformation caused by this fungus.[93] It was found by F. A. Sirrine in a swamp near Riverhead, Long Island, in 1905. The host plant was probably, *Vaccinium corymbosum,* the swamp blueberry.

Arthur,[94] in giving the distribution of *C. gœppertiana* in America, does not mention New York. Nevertheless, Peck[95] has reported its occurrence at Fulton Chain on *Vaccinium canadense* and at Sandlake on *V. corymbosum.* In 1909, Prof. Whetzel found it at Labrador Lake, near Tully, and in May, 1910, he and Dr. Reddick took another specimen from the same locality.

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90 Host Herbarium Specimen No. 14.
91 Host Herbarium Specimen No. 15.
92 Stewart and Blodgett (147, p. 287).
93 Museum Specimen No. 97.
94 Arthur (6).
95 Peck (96, p. 112). Reported under the name *Cryptospora gœppertiana,* which is evidently a slip of the pen.

Peridermium columnare Schm. & Kze., the æcial form of *C. gœppertiana* has been unknown to America until last year when it was discovered at Pictou, Nova Scotia, on leaves of balsam.[96] The fungus which Peck[97] found on hemlock leaves at Sandlake, N. Y., some 30 years ago and identified as *Peridermium columnare* proved to be a different species and was subsequently described by von Thümen under the name *Peridermium peckii.* It is now known as *Æcidium peckii* (Thm.) Diet.

BOX.

Buxus sempervirens.

CUTTINGS FAIL TO ROOT.[98] While inspecting a Geneva greenhouse during January, 1910, a small bed of imported box-tree cuttings attracted the writer's attention. Many of the cuttings had failed to root. An examination showed that the stem, and in some cases also the leaves, of all that had failed were covered with conspicuous, black, erumpent pycnidia.[99] In all cases the fungus invasion progressed from the basal toward the apical portion of the cutting. Invariably, the portion of the cutting covered by the sand was the part most seriously affected. The diseased cuttings were freely intermixed with healthy ones and no one portion of the bed seemed more seriously affected than another. To what extent the fungus is responsible for the failure of the cuttings is not clear; but its constant occurrence on affected cuttings, even on those still partly green, indicates that it is a factor in the trouble. Neither is it known how the cuttings became infected — whether from the mother plant or from the soil in the cutting bench.

The fungus was determined by Mr. Chas. H. Peck to be *Phoma stictica* B. & Br. It is interesting to note that this form was regarded by Nitschke[100] as the spermagonial stage of *Diaporthe*

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[96] Fraser (42).
[97] Peck (89, p. 61).
[98] By S. M. McMurran.
[99] Host Herbarium Specimen No. 16.
[100] Nitschke (84, p. 305).

retecta Fckl. & Nits. and identical with the *Cytospora buxi* of Desmazieres. Allescher[1] regards *Ph. stictica* as synonymous with *D. retecta*, but gives *Cytospora buxi* Desm. as an independent species.

BRUSSELS SPROUTS.

Brassica oleracea.

Club-root, *Plasmodiophora brassicæ* Wor. In 1901 a field of brussels sprouts at Mattituck, containing 2.5 acres, was completely ruined by club-root. Over the entire field the plants all collapsed at practically the same time, about September 5. Traces of the disease were found in several other fields, but after a rather thorough examination of many fields in the vicinity of Cutchogue, Mattituck and Riverhead the conclusion was reached that club-root was not very troublesome there in 1901.

CARNATION.

Dianthus caryophyllus.

Cohesion of petals. In March, 1907, a florist at Ulster Park, N. Y., sent to the Station some carnation blooms (variety, Wm. Scott) which were not opening properly because of the cohesion of the petals. The sender stated that the varieties Eldorado and Fisher were similarly affected. The petals were well out of the calyx, but stuck together. Upon examination it was found that, in some cases, the petals were actually grown together to such an extent that it was impossible to separate them without tearing the tissues. This is the only instance of the kind coming under our personal observation. However, the same trouble was described in 1896 by Arthur[2] whose studies were made on material from Jamestown, N. Y. It has also been mentioned, occasionally, in the floricultural journals.[3] The cause is not known.

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1 Allescher (3, pp. 183 and 571).
2 Arthur (5).
3 *Am. Gardening* 17 (1896):145; *Florists' Ex.* 8 (1896):167, 197, 214, 242; 17 (1904):401.

CEDAR.

Juniperus virginiana.

RUST, *Gymnosporangium nidus-avis* Thax. The object of the following note is to call attention to the fact that *Gymnosporangium nidus-avis* brings about *reversion to the juvenile form* in the branches attacked by it. In their youth many plants have a form or habit more or less different from that of the mature plant. In such cases the form assumed by the plant when young is known as its juvenile form. In the juvenile form of the red cedar, *Juniperus virginiana,* the leaves are linear-lanceolate, spiny-pointed, spreading, 1 cm. (nearly one-half inch) long; while on older trees they are scale-like, rhombic, imbricated, 1.5 mm. (one-sixteenth inch) long. Frequently, both sorts of leaves may be found on the same plant.

Gymnosporangium nidus-avis is an heterœcious rust first described by Thaxter in 1891.[4] Its æcia occur on the leaves of quince and the leaves, stems and fruit of *Amelanchier canadensis;* while in the telial stage it attacks the trunks and branches of red cedar, producing the so-called "bird's nest" distortions which consist of dense clusters of short branches.

On the north shore of Long Island, where *G. nidus-avis* is exceedingly common in the red cedar thickets, the leaves on the affected branches in the "bird's nests" are quite generally like those of the juvenile form; that is, the attack of the fungus causes reversion to the juvenile form.[5] This is not a new observation. An account of it was published by Jackson[6] eleven years ago. It has also been mentioned by Freeman.[7] But it appears to be still unknown to many botanists. In 1905, Klebahn,[8] writing of an instance in which reversion to the juvenile form resulted

[4] Thaxter (155).
[5] Museum Specimen No. 89.
[6] Jackson (66, p. 118).
[7] Freeman (43, p. 55); Pammel (87, p. 29); and others have noted that the leaves on affected branches are larger than normal and spiny, but seem not to have recognized it as a case of reversion to the juvenile form.
[8] Klebahn (69, p. 90).

from the artificial infection of *Pinus strobus* with *Cronartium ribicola,* made a statement which we translate from the German as follows: "The case of plant parasites as the cause of reversion appears to me not to be supported by especially numerous definite observations. I find only an account by Schäffer, according to which needles instead of scale-like leaves appear on *Juniperus sabina* in consequence of fungus attack, and, moreover, this account is not very exact since the fungus which was presumably *Gymnosporangium sabinæ* (or *confusum*) was designated as *Peronospora juniperina.*" Klebahn seems to have overlooked Jackson's paper above mentioned.

This case of *Gymnosporangium nidus-avis* is certainly a striking example of reversion to the juvenile form caused by the attack of a parasitic fungus. It is also instructive, since the manner in which the reversion is brought about seems to be clear.

The causes inducing reversion to the juvenile form are said to be various. Beyerinck[9] says that "all circumstances which prejudice nutrition favor the retention of the juvenile character;" also, that reversion to the juvenile form may result from injuries by frost, insects, plant parasites and wounding of the roots; but he cites no example of a plant parasite causing it. Goebel[10] states that his experiments have shown that in a number of instances reversion to the juvenile form takes place chiefly when the conditions of vegetation are unfavorably influenced, as for example, when certain water plants were wintered as land plants. Goebel says further:[11] "We may say generally that the reversion shoots appear at definite places and usually near the base of the plant." This, he says, is the case in certain genera of the Cupressineæ. Schäffer[12] says: "It is by no means always defective nutrition which leads to the production of reversion forms;" also, that there have been made abundant observations showing that old stems and branches produce the juvenile form mostly as the result of more vigorous nutrition.

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[9] Beyerinck (14).
[10] Goebel (46, p. 171).
[11] Loc. cit. p. 173.
[12] Schäffer (119).

Our case of reversion in the red cedar is plainly of the kind described by Schäffer. Instead of occurring near the base of the tree the "bird's nests" are found in any part of the tree top. The writer has seen large specimens occupying the extreme top of the tree.[13] The reversion here is clearly the result of increased metabolism. The effect of the fungus is to stimulate rapid growth in the affected branches and it is on the most rapidly growing shoots that the reversion is most pronounced. In some of the "bird's nests" the fungus, for some reason, dies out. In such cases there is little or no evidence of reversion. There are, also, intermediate forms in which the fungus is more or less active and the greater the activity of the fungus the more pronounced the reversion.

That the juvenile form in the red cedar is favored by good nutrition is shown by the fact that it persists longest in vigorous shoots. Sargent,[14] speaking of the kind of leaves characteristic of the juvenile form, says that they occur "on young plants and vigorous branches."

From an examination of the literature of the subject it appears that there are recorded only three examples[15] of reversion to the juvenile form caused by parasitic fungi, viz.:

(1) *Peronospora juniperina* (probably *Gymnosporangium* sp.) on *Juniperus sabina*, recorded by Schäffer;[16]

(2) *Cronartium ribicola* on *Pinus strobus*, recorded by Klebahn;[17]

(3) *Gymnosporangium nidus-avis* on *Juniperus virginiana*, recorded by Jackson;[18]

Perhaps a critical study of the numerous witches' brooms caused by fungi would enlarge this list.

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13 Museum Specimen No. 134.

14 Sargent (118).

15 Halsted (50) has described and illustrated reversion in the red cedar caused by *Gymnosporangium clavipes* C. & P. This may be a fourth example, but it is not improbable that the fungus was incorrectly determined and that it was, in reality, *G. nidus-avis*.

16 Schäffer (119).

17 Klebahn (69, pp. 86–91).

18 Jackson (66, p. 118).

CHERRY.

Prunus spp.

BROWN ROT, *Sclerotinia fructigena* (Pers.) Schroet. On May 24th, 1909, at the time cherries were just going out of bloom, a Geneva fruit grower brought to the Station some branches of sour cherry showing a large percentage of the blossoms brown and blighted. He reported the damage considerable and stated that in 1908 the same trouble had practically ruined his crop. Casual examination failed to detect the presence of any fungus, but when the blighted blossoms were placed in moist chamber 80 per ct. of them developed a copious growth of Monilia in 40 hours. It is likely that the blossoms were killed by Monilia. Arthur[19] reports that Monilia killed cherry blossoms at Geneva in 1885. In the spring of 1905 two trees of Heiderman sand cherry on the Station grounds lost most of their blossoms from Monilia. This variety appears especially susceptible to Monilia attack. Besides the blossoms, so many branches were killed by the Monilia that fully one-half the foliage on the trees died. The following varieties of plums adjacent were entirely unaffected: Newark, Miles and a seedling of Bavay Green Gage.

At Highland, June 13th, 1901, we observed several English Morello cherry trees on which Monilia had killed large numbers of small twigs two to four inches long. On most of the dead twigs Monilia was fruiting profusely. At the base of each dead twig gum had collected underneath the bark. Frequently, there was an exudation of gum at this point. In July of the same season a similar condition was found to exist in an orchard of English Morello cherries at Geneva. Every tree showed a considerable number of twigs killed by Monilia.

Sometimes, cherry twigs are killed by the fruit bark-beetle, *Scolytus rugulosus*.[20] In such cases, the general appearance of the affected tree is strikingly like that of trees attacked by Monilia twig blight.

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[19] Arthur (4, p. 282).
[20] Lowe (75, p. 122).

In the spring of 1908 a large percentage of the sweet cherries at Milton, N. Y., were destroyed by Monilia while they were still quite young and green — about the size of large peas. Some of the diseased fruits were brown throughout and covered with Monilia, while others were only partly destroyed by a dry brown rot.

BLACK CHERRY TWIG BLIGHT, *Sclerotinia seaveri* Rehm. The wild black cherry, *Prunus serotina,* is subject to a twig blight caused by a fungus the conidial stage of which was named by Peck *Oidium destruens.*[21] Some mycologists hold it to be identical with *Monilia linhartiana* Sacc., which causes a similar disease of *Prunus padus* in Europe. The name *Sclerotinia seaveri* is used here because Reade[22] has recently shown this fungus to be the ascogenous form of Peck's *Oidium destruens* (= *Monilia seaveri* Reade).

In gross characters, the black cherry twig blight considerably resembles the Monilia twig blight of sour cherry, the chief difference being that the leaves on affected twigs are usually well covered with the spore masses of the fungus, whereas *Monilia fructigena* rarely fruits on the leaves. Even a hasty microscopic examination might not reveal the difference between the two diseases since *M. seaveri* is very much like *M. fructigena,* except that the spores are only about half as large.

Nearly every season since 1895 the writer has observed wild black cherry trees on Long Island much affected by this disease. It occurs in practically all parts of the State, often quite abundantly, but it is on Long Island that the fungus attains its best development.[23] It is there seen at its best about June 1st. During the first week of June, 1904, there was an epidemic of the disease on Long Island. In some cases 25 to 40 per ct. of the leaves were killed. All through the tops of the trees there were small clusters of dead brown leaves. Upon examination it was found that not only were the leaves affected, but also the shoots

[21] Peck (90, p. 41).
[22] Reade (106).
[23] Host Herbarium Specimen No. 17.

of the current season's growth were dead.[24] The dead shoots were rarely more than 8 cm. (three inches) long and usually bore two to four leaves each. Both shoots and leaves were covered with a gray powder composed chiefly of the spores of the Monilia. On the leaves, the fungus shows a marked tendency to fruit in the vicinity of the large veins, particularly the midrib. It occurs on both surfaces of the leaf, but more abundantly on the upper surface.

This disease is of small economic importance here because the host plant has little value in this State.

WITCHES' BROOMS, *Exoascus cerasi* (Fckl.) Sadeb.[25] The writer has previously noted the sparing occurrence of this disease at various places in the State, particularly on Long Island.[26] There is no reason to believe that it will ever become troublesome here. It shows little inclination to spread.

We first became acquainted with this disease in May, 1895, when it was discovered on a single tree of a small-fruited variety of sweet cherry (*Prunus avium*) at Queens, Long Island. Nine years later (May, 1904), this tree was again examined. It was now about 45 cm. (18 inches) in diameter and bore several Exoascus "brooms," but, apparently, it had not suffered from the disease. Moreover, another tree of the same variety standing only five meters (16 feet) distant was entirely free from the disease notwithstanding branches of the two trees interlocked.

POWDERY MILDEW, *Podosphæra oxyacanthæ* (DC.) DeBy. This is a common and sometimes destructive disease of cherries in New York nurseries. In autumn it frequently attacks, also, bearing cherry trees, showing a preference for leaves at the tips of succulent growing shoots.

The mahaleb cherry, *Prunus mahaleb,* appears to be immune to mildew. In October, 1901, the writer observed, near Geneva, a block of sweet cherry nursery trees which were severely attacked

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24 Peck does not mention its occurrence on the shoots.

25 Host Herbarium Specimens Nos. 18, 19, 20 and Museum Specimen No. 135.

26 Stewart (137; 138, p. 532; 152, p. 309).

by powdery mildew. The trees had been budded on mahaleb stocks. In a considerable number of cases the buds had failed to "take" and the tops of such stocks had been permitted to grow instead of being cut off just above the point of budding according to the usual custom when the buds grow. Invariably, these mahaleb trees were absolutely free from mildew although closely surrounded by the badly mildewed sweet cherries.

The variety Gov. Wood, a sweet cherry (*Prunus avium*), likewise appears immune to mildew. In a Geneva nursery, two rows of this variety 300 meters (60 rods) long were entirely free from powdery mildew, while the two adjacent rows of the variety English Morello were badly mildewed throughout their whole length. Ten rows of the variety Hoy, near by, were nearly, but not quite, free from mildew. The following other varieties were more or less affected: Baldwin, Bing, Black Tartarian, Dikeman (slightly), Early Richmond (very badly), Lambert (badly), Montmorency (badly), Napoleon Bigarreau, Windsor and Waterloo. These observations were made in October, 1909.

CHOKE CHERRY FRUIT SPOT, *Cylindrosporium padi* Karst. In July, 1910, the green fruits of some choke cherry trees (*Prunus virginiana*) on the Station grounds were severely attacked by a fungus disease which manifested itself in the form of dead brown spots.[27] Cylindrosporium acervuli well filled with spores were to be found on nearly all of the spots. Similar acervuli appeared on spots on the fruit-stems and pedicels; also, on circular dead brown spots on the leaves. The disease was so virulent that only a few of the fruits matured and the trees were almost completely defoliated. The writer is of the opinion that the fungus on the fruit and fruit-stems was the same as that on the leaves and referable to *Cylindrosporium padi* Karst. It appears that the occurrence of this fungus on cherry fruit is unusual, although it is exceedingly common on cherry leaves, and the writer has observed the fruit pedicels of sour cherries abundantly infested with it.[28] A fungus causing a strikingly similar disease

[27] Museum Specimen No. 136.
[28] Stewart and Eustace (149, pp. 85–87).

of the green fruits of the European bird cherry, *Prunus padus,* in Europe has been named *Cylindrosporium tubeufianum* by Allescher;[29] but Aderhold,[30] upon making a careful comparison, failed to find any essential difference between *C. tubeufianum* and *C. padi.* Probably, the former name is to be considered a synonym of the latter.

CHESTNUT.

Castanea dentata.

CANKER, *Valsonectria parasitica* (Murr.) Rehm. An excellent example of the manner in which the fungus gains entrance through wounds in the bark was observed at Hicksville in October, 1909. The trunks of two small chestnut trees crossed in such manner that they touched at one point. The swaying of the trees by the wind caused a slight abrasion of the bark on both trunks at the point of contact. Each tree showed a large canker centering about the abraded spot and these were the only cankers to be found anywhere on either trunk. The Valsonectria was in the ascosporic stage.[31]

CHRYSANTHEMUM.

Chrysanthemum sp.

BLACK SPECK, *Pilobolus crystallinus* (Wigg.) Tode. In December, 1909, we received from Lockport some chrysanthemum leaves covered with small round black specks.[32] The sender stated that the greenhouse containing the affected plants had been recently fumigated by burning tobacco stems. He wished to know why the smoke had settled on the leaves in this manner, since such spotting of the foliage was very objectionable.

The black specks were plentiful on both surfaces of the leaves. They were readily visible to the unaided eye. Under a hand lens they resembled in a striking manner the pycnidia or perithecia of some fungus. When examined with a compound microscope they appeared as circular black bodies 300–500 μ in diameter, often

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[29] von Tubeuf (159, p. 504).
[30] Aderhold (1, p. 808).
[31] Museum Specimen No. 96.
[32] Host Herbarium Specimen No. 21.

bearing a few short brown appendages. The black bodies contained multitudes of elliptical, non-septate, slightly yellowish spores measuring 6 x 10 μ. Seen in mass, the spores appeared distinctly yellowish-brown.

The sender was informed that the black specks were the sporangia (spore masses) of *Pilobolus crystallinus,* a fungus which grows on fresh manure everywhere. The sporangiophores are provided with a mechanism which throws off the ripe spores with so much force that they are carried a distance of a meter or more. Being covered with a mucilaginous substance they readily adhere to whatever they strike — leaves, wood-work or glass.

Subsequently, it was reported to us that it was cow manure which had been used in the above-mentioned case; that the trouble appeared from three to five days after the application of the manure; and that the spore masses were thrown about 120 cm. (four feet).

Owing to the frequent use of fresh manure about roses under glass it is on rose leaves that the Pilobolus sporangia most frequently attract attention. Their occurrence on rose leaves has been recorded by Craig,[33] who states that the trouble was promptly arrested by a light application of air-slaked lime; by Stone and Smith,[34] who have illustrated the fungus and explained the method by which the sporangia are abjected; and by Halsted,[35] who observed sporangia thrown to a distance of ten feet. An amusing explanation of the origin of the black specks is given by May,[36] a florist, who states that they are due to the condensation of ammonia arising from fresh manure. Even professional mycologists have been deceived by them. According to Farlow,[37] the fungus bodies described by Peck[38] as parasitic on rose leaves under the name *Leptothyrium chromospermum* were, in reality, the discharged sporangia of *Pilobolus.*

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[33] Craig (23, p. 118). The fungus is called "Mucor," but this is plainly an error. The description given shows that the fungus was Pilobolus.

[34] Stone and Smith (153).

[35] Halsted (55, p. 333).

[36] May (81).

[37] Farlow (36).

[38] Peck (93).

CLEMATIS.

Clematis sp.

LEAF-SPOT, *Cylindrosporium clematidis* E. & E. var. *jackmanii* E. & E. The Host Herbarium contains specimens[39] which appear to belong to the same collection as the specimens upon which Ellis and Everhart[40] based their description of the var. *jackmanii.*

Specimens of the same fungus collected by S. A. Beach[41] are accompanied by the following note signed by Prof. Beach:— "On different varieties of clematis in the propagating houses of Selover and Atwood, Geneva, N. Y. Not doing serious damage, but causing the loss of a few lower leaves from many plants. April 10, 1893."

COREOPSIS.

Coreopsis tinctoria.

POWDERY MILDEW, *Erysiphe cichoracearum* DC. On September 15, 1899, some plants of *Coreopsis tinctoria* growing on the Station grounds were found to be affected with a powdery mildew which proved to be *Erysiphe cichoracearum.*[42] On a few of the plants perithecia were numerous on both stems and leaves. Such of the perithecia as were mature contained several two-spored asci. *E. cichoracearum* occurs on many species of plants, but we are unaware of its having been reported previously on any species of Coreopsis.

COSMOS.

Cosmos bipinnatus.

FASCIATION. In December, 1907, a single branch of a cosmos plant growing in the Station greenhouse showed a pronounced case of fasciation. It was about 25 mm. wide, leafy throughout and bore two normal flowers.[43]

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[39] Host Herbarium Specimen No. 22.
[40] Ellis and Everhart (33, p. 155).
[41] Host Herbarium Specimen No. 23.
[42] Host Herbarium Specimen No. 24.
[43] Host Herbarium Specimen No. 25.

POWDERY MILDEW, *Erysiphe cichoracearum* DC. In 1899 and 1907 cosmos plants in the Station greenhouse were severely attacked by *Erysiphe cichoracearum* DC. Another, milder, attack occurred in the autumn of 1909, when plants in the open as well as those under glass were affected.

In 1907, traces of mildew appeared November 4. On November 29 a few mature perithecia were found. By December 11 the leaves and smaller branches of the plants were completely overrun with mildew. On branches, it rarely occurred on those over 6 mm. (one-fourth inch) in diameter. Perithecia were plentiful on leaves, branches, involucral scales and especially on the flower pedicels.[44]

In 1909, no perithecia could be found on the plants in the open until after October 6, but by October 28 mature perithecia were abundant. As a rule, the asci contained two sporidia each, but a few three-spored asci were found.

Apparently, the only previous reference to a powdery mildew on cosmos is found in a single sentence by Halsted, who says:[45] "A mildew (*Erysiphe cichoracearum*) so abundant upon many other of the Compositæ is frequently seen upon the foliage of the cosmos."

STEM BLIGHT, *Phomopsis stewartii* Pk. The present literature of this disease consists of a popular account by Halsted,[46] a note by Halsted[47] on a spraying experiment in which eight applications of bordeaux failed to prevent it, and a note by Clinton[48] on its occurrence in Connecticut. Our own studies upon it have been conducted intermittently from 1899 to the present time. In 1901 and 1902 Prof. H. J. Eustace, then Assistant Botanist of this Station, made cultural studies of the causal fungus and some inoculation experiments. Each year since 1899 the disease has regularly made its appearance among cosmos plants grown at the Station. Generally, it has attacked the plants both in the field and in the greenhouse and caused much damage.[49]

[44] Host Herbarium Specimens Nos. 26 and 27.
[45] Halsted (52, p. 464).
[46] Halsted (52). See also Halsted (53, p. 371).
[47] Halsted (54, p. 400).
[48] Clinton (20, p. 318).
[49] Host Herbarium Specimens Nos. 28 and 29.

Stem blight is a disease of mature cosmos plants. Young plants are not affected. August 23 is the earliest we have known it to appear. It is most destructive in the greenhouse, but plants blooming in the open may be severely attacked during September and October. The point of attack may be anywhere on the stem or branches, but never on the leaves or roots. First, there appears on the green stem a brown spot which rapidly enlarges until it nearly or quite encircles the stem. A section of the stem several inches in length becomes involved. Then the parts above suddenly wilt and die. The diseased section of the stem is hollow, while above and below the point of injury the stem is nearly or quite solid, the pith being firm, green and water soaked.

The bark and pith are thoroughly permeated by fungus hyphæ. In the cavity formed by the disintegration of the pith, hyphæ are frequently so abundant as to be readily visible to the unaided eye. On the surface of the stem small pycnidia appear in great abundance. The pycnidia contain two kinds of spores — filiform, hyaline spores curved at one end like a fish hook, and oblong, binucleate, hyaline spores measuring about 3 x 10 μ. The existence of two kinds of spores was discovered by the writer in 1899 and has been observed repeatedly since. It is a regular occurrence. Sometimes one spore form predominates, sometimes the other. Even with a good hand lens we have been unable to distinguish the pycnidia containing one kind of spores from those containing the other kind. By means of sections it was learned that the two kinds of spores frequently occur in the same pycnidium. At first, it was suspected that the two kinds of spores belonged to two separate species of fungi, one of which was parasitic upon the other. But, subsequently, it was conclusively proven, by means of pure cultures, that they belong to one and the same fungus. Some difficulty was experienced in obtaining pure cultures of the fungus. It does not grow well on potato agar. The best success was secured with unneutralized alfalfa agar and sterilized alfalfa stems. On both these media it grows and fruits readily, producing both kinds

of spores. In our cultures, the oblong spores have been the first to appear.

That the fungus is a parasite and the cause of the disease there can be no doubt. This is shown by its constant association with the disease at the seat of the trouble while wholly absent from other dead parts of the plant. In ten years' study of the disease we have never found any other fungus in connection with it. Nevertheless, it appears to be somewhat difficult to reproduce the disease by artificial inoculation, either with pure cultures of the fungus or with bits of diseased tissue. Both methods have been tried by Prof. Eustace and also by the writer without any definite success. In such experiments there have been several instances in which a natural infection, occurring lower down, has killed the inoculated branch before the appearance of any discoloration of the bark at the point of inoculation notwithstanding the branch was apparently unblemished at the time of making the inoculation.

Halsted, who seems to have observed only the filiform spores, referred the fungus to the genus Phlyctæna. Taken by itself, the form with oblong spores is referable to the genus Phoma. But the occurrence of the two spore forms together in the same pycnidium complicates things so much that the writer found it necessary to refer the matter to an expert systematist. Accordingly, specimens were submitted to Dr. C. H. Peck, who has named the fungus *Phomopsis stewartii* and described it as follows:[50] "Perithecia gregarious, commonly occupying grayish or brown spots, thin, subcutaneous, at length erumpent, depressed, minute, 1/3 – 1/2 mm. broad, black; spores of two kinds, first, filiform, curved, flexuous or uncinate, hyaline, 16 – 25 x 1 – 1.5 μ, second, oblong or subfusiform, hyaline, commonly binucleate, 8 – 12 x 2–3 μ; sporophores slender, equal to or shorter than the spores."

[50] Peck (102, p. 27).

COTTONWOOD.
Populus deltoides.

Yellowing and premature falling of leaves. The following observations were made on two cottonwood trees standing close beside a small stream on the Station grounds. One tree was eleven inches in diameter, the other, nine. Almost every year the stream goes dry for a short time during midsummer. In 1909 it was dry longer than usual — from July to October — owing to a severe drought. During the early part of September many of the leaves on these trees became yellow and fell to the ground before there had been any frost. By September 10th about one-half of the leaves were golden yellow while the remainder were normally green. All leaves were either bright yellow or green — there were none partly green and partly yellow. The green leaves were those toward the ends of the branches. On the following day (September 11) there came a drizzling rain and the yellow leaves fell in showers. The fallen leaves were free from spots and browning. The only blemishes about them were conspicuous insect galls occurring on the petioles of a considerable number of the leaves. These galls were of two kinds, caused by two species of Pemphigus, *P. populicaulis* and *P. populi-transversus*.[51] But it was plain that the galls had nothing to do with the yellowing of the leaves, for they were equally abundant on the green leaves. In the course of a few days the remaining leaves turned yellow and fell. Other cottonwood trees in the vicinity, particularly small trees on the banks of the stream, were similarly affected.

This seems to have been a case of premature ripening brought about by the drought and the drying up of the stream. Probably, the trees were not much injured. They appeared normal the following season.

In the spring of 1910 the larger tree was cut down. On the other tree, yellowing of the leaves did not commence until October 7. This year there was plenty of rain during the summer and fall and no frost until October 12.

[51] Identified by H. E. Hodgkiss.

CUCUMBER.

Cucumis sativus.

POWDERY MILDEW, *Erysiphe cichoracearum* DC. ? As a greenhouse trouble, cucumber powdery mildew is probably not uncommon. In 1891 it was observed by Bailey on greenhouse cucumbers at Ithaca[52] and the writer has personal knowledge of its destructive occurrence in certain greenhouses at Irondequoit in 1900, 1902 and 1905. The writer[53] has also reported its occurrence on field-grown cucumbers at Athens, Pennsylvania, in 1899, but, in New York, we have never known it to attack plants in the open until 1909.

In 1909, Mr. C. R. White, Ionia, N. Y., sent us some leaves of field-grown cucumbers affected with powdery mildew. He stated that his entire field of nine acres had been considerably injured by it; also, that other fields in the vicinity were affected. The leaves sent showed no perithecia. In fact, the writer has never seen perithecia on cucumber leaves. Hence, the fungus can not be identified with certainty, but it is probably *Erysiphe cichoracearum*. Perithecia found by Humphrey[54] on greenhouse cucumbers in Massachusetts belonged to this species and Reed's cross-inoculation experiments with *E. cichoracearum* show that it grows readily on cucumber leaves.[55]

DAHLIA.

Dahlia varabilis.

POWDERY MILDEW, *Erysiphe cichoracearum* DC. This fungus was found in considerable abundance on the leaves and stems of cultivated dahlias at Cutchogue, Long Island, in October, 1909. Mature perithecia were plentiful on both surfaces of the leaves and also on the stems.[56] It has been reported on cultivated

[52] Humphrey (62); Bailey (11, p. 138).
[53] Stewart (140, p. 213).
[54] Humphrey (63 and 64).
[55] Reed (107).
[56] Host Herbarium Specimens Nos. 30 and 31.

dahlias in Ohio by Selby and in Connecticut by Clinton. Another powdery mildew, *Erysiphe communis* (Wallr.) Fr. (=*E. polygoni* DC.) has been reported by Tracy and Galloway[57] as occurring on dahlias in Missouri.

GRAPE.
Vitis spp.

POWDERY MILDEW, *Uncinula necator* (Schw.) Burr. F. L. Stevens has described and illustrated the curious instance of some grape leaves on which the tortuous trail of some small animal was plainly marked by a growth of the white mycelium of *Uncinula necator.* Stevens' observations were made at Columbus, Ohio, in September, 1898.

The same thing was observed by the writer at Geneva, N. Y., September 13, 1898.[59] In this case, the grape was of the variety Wilder and growing against the north side of a house. For the most part, the mildew grew only on the track of the animal (Plate XIII), but on some of the affected leaves there were also circular mildew spots of the normal kind. Ripe perithecia were found and these showed the mildew to be *Uncinula necator.* The mildew was freely parasitized by *Cicinnobolus cesatii* DeBy. Ten years later (1908) the phenomenon was observed a second time on the same grape vine. We have seen, also, specimens collected at Fredonia, N. Y., in 1909, by F. Z. Hartzell.

Stevens did not learn the identity of the animal. He suggested that it may be a worm or snail which crawls over the leaf, leaving behind it a trail of its glutinous secretion. He states that "sections show the track to be purely superficial." This appears to be an error. Observations made by Mr. F. Z. Hartzell, Assistant Entomologist of this Station, show that the track is made by a leaf-mining larva working under the upper epidermis of the

57 Tracy and Galloway (158).
58 Stevens (136).
59 Host Herbarium Specimen No. 32.

leaf.[60] Mr. Hartzell's studies were made in Chautauqua County, but the writer has seen his specimens and is convinced that they are identical with those found at Geneva and, probably, also with those studied by Stevens.

To account for the peculiar distribution of the fungus Stevens advances the theory that spores of the fungus are scattered by the animal. Such can scarcely be the case, because it is probable that the larva making the mine enters the leaf as soon as it is hatched and so has no opportunity of getting the spores onto its body. To the writer it appears plain that the fungus finds more favorable conditions for its growth along the trail of the larva than on the uninjured tissue bordering the trail; but why this is so is not clear. It is difficult to explain why a strict parasite (which this fungus is supposed to be) should prefer injured tissue.

BORDEAUX INJURY. The following observation indicates that the variety Cottage is more liable to bordeaux injury than the variety Delaware. A vineyard at Highland contains several rows in which some of the plants are of the Cottage variety while others are Delawares. In the spring of 1909, just before blooming, these rows were sprayed with bordeaux mixture each fifty gallons of which contained five pounds of copper sulphate and sufficient lime to satisfy the potassium ferrocyanide test. When the writer examined the vineyard on June 17 the Cottage plants

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[60] The insect referred to above is the larva of a Tineid moth bearing the name *Phyllocnistis vitigenella* Clemens. The moth is silvery white with a black spot and several lines near the distal end of the wing. It has an alar expanse of five millimeters. The larva makes a serpentine mine underneath the upper epidermis of the leaf by feeding on the palisade cells and perhaps on a few cells of the spongy parenchyma, but does not eat through to the lower epidermis. For this reason the mine is not transparent and the drying of the epidermis causes the mine to have the appearance of a snail's track. Chambers' statement (19, p. 192) that "the larva hardly burrows through the cuticle, and does not go down into the parenchyma" is incorrect. The sub-epidermal character of the mine is difficult to demonstrate by freehand sections, but the presence of an epidermis over the mines is proven by the fact that it can be lifted by means of a dissecting needle.

The moths and their mines were quite numerous on Concord grape leaves during the summers of 1909 and 1910 at Fredonia, N. Y. Pupæ were taken from July 20 to August 23 and the adults emerged from July 22 to September 16. The adults are said to hibernate under the rough bark of trees and perhaps in other secure hiding places. Only one larva was taken.—F. Z. Hartzell.

were showing considerable spray injury which manifested itself in the form of large, irregular dead brown areas on the leaves. At the same time the foliage of the Delawares was perfect.

HEPATICA.

Hepatica acutiloba.

DOWNY MILDEW, *Plasmopara pygmæa* (Ung.) Schrt. A resident of Geneva has a bed of *Hepatica acutiloba* planted in a thicket of small trees in his yard. In May, 1909, he called the writer's attention to a disease which was ruining the foliage of the Hepatica plants. He stated that the plants had been similarly affected the preceding season. Upon examination it was found that the trouble was due to the fungus *Plasmopara pygmæa*[61] which was so abundant that nearly all of the leaves were killed by it before June 1.

In the spring of 1910 the disease reappeared. Our first observations were made on April 8th, at which time the plants were already in full bloom, the spring being unusually early. The majority of the plants then appeared healthy, but there were a few the leaves of which were dwarfed and distorted and covered with Plasmopara conidia. On June 13th affected leaves were showing large, irregular, dead, brown (sometimes yellowish) areas. Oöspores, 14–17 μ in diameter, were now plentiful.[62] This season the disease was much less destructive than in 1909, owing, probably, to the plants having been sprayed twice with bordeaux mixture.

The owner informs us that the plants in this bed were taken, a few years ago, from another bed less than 100 feet distant on the opposite side of his yard. It is an interesting fact that not even a trace of the disease has ever appeared on any of the plants in the parent bed, notwithstanding they are in the shade and otherwise treated in essentially the same manner as the plants in the diseased bed. From this it appears that the disease does not

[61] Host Herbarium Specimen No. 33.
[62] Host Herbarium Specimen No. 34.

spread readily. Prof. Whetzel is of the opinion that the fungus perpetuates itself by means of a perennial mycelium as well as by oöspores.[63]

HOLLYHOCK.

Althœa rosea.

RUST, *Puccinia malvacearum* Mont. This is a common and often destructive disease of hollyhocks in New York. In October, 1909, the writer's attention was attracted by the peculiar appearance of some rust-infested leaves of hollyhocks growing on the Station grounds.[64] Viewed from the upper surface the affected leaves showed small, white, slightly sunken spots about one millimeter in diameter. With the aid of a hand lens a few small. black pycnidia could be seen on some of the spots. The majority of these pycnidia proved to be those of an Ascochyta, but some were Septoria pycnidia. On the under surface of the leaf opposite the white spot, there was invariably a rust sorus. Apparently, the Ascochyta and Septoria were growing parasitically upon the Puccinia.

On April 21, 1910, further observations were made on the same plants. Already, the leaves were thickly covered with rust sori. Some of the lower leaves showed conspicuous brown spots, each of which had a stunted rust sorus in the center on the under side of the leaf. No trace of Ascochyta or Septoria could be found

[63] In a letter dated Oct. 8, 1910, he says:—"My opinion as to the perennial habit of the mycelium of *Plasmopara pygmœa* (Ung.) Schrt. is based upon observations covering several years and also upon an experiment which I carried out for the past three years. Having frequently observed that individual plants here and there in a large hepatica patch in the forest were affected with this mildew and that the parasite not only seemed to infest the entire plant but did not seem to spread to any great extent to the neighboring plants, I took up several of these diseased plants, and transplanted them to a shady spot in my garden. This was in the spring of 1907. The diseased leaves soon died down after transplanting. The next spring, the roots sent up leaves again, which, *as soon as they appeared*, showed that they were diseased, being small, distorted, and covered with conidiophores in a very short time after they appeared. Practically every leaf on the plant was diseased. In the spring of 1909 and 1910, only a few leaves appeared from the roots. These were likewise diseased and died down quickly. It appears that the disease slowly kills the plant. From this it seems almost certain that the mycelium must be perennial in the roots of the plant."

[64] Host Herbarium Specimen No. 35.

at this time. By June 2d, the dead brown spots had become numerous. They were circular, 3 to 6 mm. in diameter and sharply defined.[65] The central portion was slightly sunken but not white. Occasional spots bore pycnidia of the Septoria observed in 1909. Other spots bore pycnidia of a Phyllosticta. Occasionally, rust sori on the leaf petioles were surrounded by pycnidia of Ascochyta in exactly the same manner that pycnidia of *Darluca filum* are associated with the rust sori parasitized by it. However, the spores of the Ascochyta are broadly rounded at both ends and commonly measure $4 \times 10\,\mu$ while those of *Darluca filum* are distinctly fusoid and measure $4 \times 17\,\mu$. The Septoria spores are usually three-septate and measure 3.5–4 x 30–45 μ.

The Ascochyta is probably *A. parasitica* Fautrey and the Septoria, *S. parasitica* Fautrey. Fautrey[66] has observed a similar association of these fungi with *Puccinia malvacearum.* Clinton[67] also, states that, in Connecticut, *Ascochyta parasitica* occurs on hollyhock leaves associated with rust pustules.

At least two other species of Septoria occur on Malvaceæ in New York; namely, *S. malvicola* E. & M.[68] on *Malva rotundifolia* and *S. fairmani* E. & E.[69] on hollyhock leaves; but both of these have narrower spores and produce spots of a different character. *Septoria parasitica* Hartig, which causes a twig blight of spruces in Europe, now bears the name *Ascochyta pinniperda* Lindau.[71]

HONEYSUCKLE.

Lonicera tatarica.

POWDERY MILDEW, *Microsphæra alni* (Wallr.) Salm. var. *loniceræ* (DC.) Salm. Salmon says:[72] "The var. *loniceræ* is confined to Europe; the numerous records of the plant on species

[65] Host Herbarium Specimen No. 36.
[66] Fautrey (37).
[67] Clinton (20, p. 326).
[68] Martin (79, p. 65).
[69] Ellis and Everhart (33, p. 151).
[70] Hartig (56).
[71] Lindau (73).
[72] Salmon (116, p. 145).

of Lonicera in America all refer to typical *M. alni*." Considering this statement it is worthy of note that specimens of the var. *lonicerœ* on leaves of Tartarian honeysuckle were collected by the writer at Geneva in September, 1909.[73] Our determination of the fungus has been confirmed by Dr. Salmon to whom specimens were sent for examination. Sixteen affected plants were found, most of them well covered with mildew, particularly on the lower leaves, but apparently none were materially injured. Twelve of the plants were scattered through a small park while the other four were in neighboring yards. Thirteen of the affected plants bore yellow fruits and the other three red fruits. Apparently, the yellow-fruited varieties are much more susceptible to mildew than is the red-fruited one. When the plants bloomed in the spring of 1910 some of the yellow-fruited ones bore white flowers (var. *alba*), while others bore light pink flowers the lobes of which were bordered with white (var. *latifolia?*). The red-fruited plants produced deep pink flowers with lobes bordered with white (var. *speciosa?*). The mildew occurs chiefly on the upper surface of the leaves, but to some extent also on the under surface. In September ripe perithecia were numerous and readily visible to the unaided eye. They are considerably larger than the perithecia of *M. alni* on lilac leaves.

In 1910, twenty-eight mildewed plants were found. The mildew commenced to appear about July 1st and by August 20th perithecia were plentiful. In one case, perithecia were found on some shriveled yellow fruits.

HOP.

Humulus lupulus.

LEAF-SPOT, *Cylindrosporium humuli* E. & E. Specimens of this on leaves of cultivated hops were collected at Oaks Corners, September 5, 1900.[74] The hop plants were but slightly injured. Other specimens were taken at Middleburgh in August, 1910.

[73] Host Herbarium Specimens Nos. 37 and 38.
[74] Host Herbarium Specimen No. 39.

Powdery mildew, *Sphærotheca humuli* (DC.) Burr.[75] During the latter part of August, 1909, hop growers in the vicinity of Waterville, N. Y., became alarmed over an outbreak of a hop disease which they called "blue mold." On September 4th the writers visited Waterville for the purpose of investigating the trouble.[76] It was found that the so-called blue mold was, in reality, a powdery mildew.[77] In one hop-yard of about four acres the crop was a total loss because of the disease. A few other yards were slightly injured. In the worst-affected yard the hops were of the Canada variety. This variety appeared more susceptible to attack than the English Cluster variety. The leaves, stems and cones were covered with a conspicuous whitish mildew. The favorite point of attack of the fungus seemed to be on the pedicel at the base of the cone. Usually, the bracts of the cone were not mildewed except at the base, but the tips of the bracts were brown and shriveled. This gave the cones a brown, scorched appearance. Also, the affected cones were much smaller than healthy ones. (Plate XV.) Apparently, the browning and dwarfing of the cones resulted from the attack of the fungus on the bracts and pedicels of the cones rather than from the attack on the leaves. Most of the foliage was but slightly mildewed. Surely the mildew was not sufficiently abundant on the foliage to cause serious injury by reducing the vitality of the plant. However, occasional branches here and there were white with mildew and many leaves were more or less spotted by it. On the leaves, the mildew appeared in conspicuous bluish-white spots and blotches or frequently covered them completely. (Plate XIV.) It occurred most abundantly on the upper surface of the leaves, but also on the under surface. On the cones, it was not conspicuous except on very small ones which were sometimes completely overgrown with mildew. In some cases of mild attack it was necessary to use a hand lens to distinguish diseased cones from healthy ones. The cone-pedicel and cone-axis are covered normally with a fine white pubescence closely resembling mildew.

[75] By F. C. Stewart and H. H. Whetzel.

[76] Brief accounts of the observations made during this visit have been published previously. See Stewart (145) and Whetzel (162).

[77] Host Herbarium Specimens Nos. 40 and 41.

Although a careful search was made for them, no perithecia were found. Hence, the fungus could not be identified with certainty. Three species of powdery mildew are said to attack hops — *Erysiphe cichoracearum*,[78] *Phyllactinia corylea*[79] and *Sphærotheca humuli*. The first two species are of rare occurrence on hops, but *Sphærotheca humuli* is a widely distributed and well-known hop parasite.

Contrary to our expectations, the mildew reappeared at Waterville in 1910 and became considerably more destructive than in 1909. Messrs. Jensen and Blodgett[80] of the New York State College of Agriculture, who went to Waterville to study the disease, report finding perithecia of *Sphærotheca humuli*. This definitely identifies the mildew occurring there as the dreaded " hop mould " or " hop mildew " of England.

On August 24, 1910, the senior author and G. G. Atwood of the State Department of Agriculture visited Middleburgh to investigate an outbreak of the mildew at that place. All hop yards in the vicinity of Middleburgh were found to be more or less affected. In some cases the loss was estimated at from 65 to 80 per ct. It is reported that the mildew appeared also at Sharon Springs and various places in Otsego County. At Middleburgh the behavior of the disease was essentially the same as at Waterville in 1909 with two exceptions, viz.: (1) Perithecia of *Sphærotheca humuli* were abundant on stems, leaves and cones;[81] (2) The Canada and English Cluster varieties appeared about equally susceptible.

Hop growers, knowing the damage done by this disease in England, fear that it may become common and destructive here. This may or may not happen. It is encouraging to note that although its occurrence on hops has been reported, occasionally, from Maine[82] to California[83] there is no record of its having caused

[78] Tracy and Galloway (158).
[79] Magnus (76).
[80] Jensen and Blodgett (67).
[81] Host Herbarium Specimen No. 42.
[82] Harvey (58, p. 50).
[83] Burrill (16, p. 5) says: "In California Dr. Harkness reports *S. castagnei* on hop leaves. This is no doubt what is here called *S. humuli*."

serious damage anywhere in America. Burrill[84] says that *S. humuli* "is a very destructive parasite, especially on cultivated hops, in the Old as well as in the New World," but he gives no details. In this connection a bit of information furnished us by Dr. B. M. Duggar is of special significance, viz., that he observed a powdery mildew on hops at Waterville about ten years ago, yet no serious outbreak of the disease followed. No other instance of the occurrence of mildew on hops in New York prior to 1909 is known to us.

Why the hop mildew should not be destructive in this country is not clear. The climate of England is moister than ours, but it is worthy of note that the seasons of 1909 and 1910 in which the Waterville and Middleburgh outbreaks occurred were exceptionally dry seasons.

In England, one of the chief methods of combating mildew consists in dusting the plants with flowers of sulphur on hot, sunshiny days.[85] Potassium sulphide solution, applied in the form of spray, has also been used. Percival[86] recommends potassium sulphide spray followed by an application of powdered sulphur. In bearing hop yards all parts of the plants above ground should be burned as soon as the crop is gathered; while young plants, not in bearing, should be left to continue their growth until killed by frost and then burned.[87]

HORSE CHESTNUT.

Aesculus hippocastanum.

RAGGED LEAVES, *frost injury*. Sorauer seems to have been the first to give (in 1903) the correct explanation of the ragged con-

[84] Loc. cit. p. 6.

[85] Whitehead (164, pp. 246–249).

[86] Percival (103, p. 734).

[87] Since *S. humuli* attacks also various species of wild plants it generally has been recommended that treatment for mildew include the destruction of susceptible weeds in and about the hop yard; but cross-inoculation experiments made by Salmon indicate that this is unnecessary. Salmon says (117, p. 332): "The whole of the evidence to hand strongly supports the view that hop 'mould' is due to one special 'biologic form' confined to *Humulus lupulus* and *H. japonicus* and that consequently hop growers have nothing to fear from other forms of *S. humuli* growing on wild plants." However, he points out that the matter cannot be considered fully settled until inoculation experiments have been made on all of the 30 or more host plants of *S. humuli*.

dition so common with horse chestnut leaves. (Plate XVI.)[88] He ascribed it to frost injury while the leaves are unfolding.[89] On the other hand, Thomas[90] has expressed the opinion that frost is secondary and that the primary and chief factor is the wind. Sorauer[91] answers this by pointing out that the lesions are not of the kind to be expected from wind injury, and that, moreover, he has seen the injury brought about by frost on trees fully protected from wind.

Our own observations indicate that the leaves of horse chestnut trees at Geneva are more or less injured by late spring frosts almost every year. It has occurred every spring during the past eight years—1903–10.

Since the injury occurs at the time the leaves are unfolding it seems desirable to give a description of horse chestnut buds and their manner of opening. Some horse chestnut buds contain both leaves and flowers; others only leaves. The former are considerably the larger and usually open earlier. There are generally six pairs of bud-scales arranged decussately. They are of different sizes — the lower, or outermost, pair being seven millimeters or less in length while the innermost are 25 to 50 mm. long. On the outside they are covered with a sticky substance. The second pair of scales often separate widely from the bud while the upper four pairs are still tightly closed over the leaves. By the time the petioles and leaf blades are each 50 mm. in length the second and third pairs of scales are reflexed while the other pairs stand upright though divergent at their tips. At Geneva, the tips of the leaves begin to show the last week in April or the first week in May.[92] Some trees leaf earlier than others. A tree on the Station grounds regularly breaks its buds a few days earlier than other trees standing on either side of it. In

88 Host Herbarium Specimen No. 43.
89 Sorauer (131, 132 and 134, p. 533).
90 Thomas (156).
91 Sorauer (133).
92 In the spring of 1910 horse chestnut trees began to show their leaves during the first week in April. As measured by the time of leafing of a certain horse chestnut tree on the Station grounds, the spring of 1910 was 24 days earlier than that of 1909.

1909 the difference was seven days. (Plate XVII.) Even on the same tree some buds break a week earlier than others. In the bud, each of the seven leaflets is folded by the midrib so that the two halves are placed face to face. On each side of the midrib the folding is fan fashion so that the large lateral veins are arranged in parallel lines on the outside and the folds of the intervening parenchyma inside. While in the bud, the leaves are thickly covered on the back and petioles with matted, woolly white hairs. When the bud breaks, exposing the leaves to the light, the hairs become light brown or tawny and gradually fall away as the leaves expand.

At Geneva, one or more light frosts occur between May 1st and 15th almost every year. Any time during this period a temperature of 31° F. or lower will cause injury to horse chestnut leaves. During the night of May 1, 1905, the self-registering maximum and minimum thermometer on the Station grounds registered 29.5° F. At this time horse chestnut leaves were breaking from the buds and showing 25 to 40 mm. (1 to 1.6 inches) of their tips. (Plate XVIII, fig. 1.) On May 5th the partially expanded leaves showed shiny, light-brown, water-soaked spots in the parenchyma between the veins. By May 12 some of the leaves were already showing the characteristic comb-like appearance. On May 15th the following observations were made: Where the injury was slight the spots were depressed, water-soaked in appearance and very shiny. Often they occurred in a straight line between the larger veins. Where the injury was more severe the spots were light brown with a yellowish margin; and where the injury was very severe the dead tissue had fallen completely away leaving irregular holes as clean cut as if made by some biting insect. In 1906, frost (30° F.) occurred on the night of May 10th when the blades of horse chestnut leaves were 50 to 125 mm. (2 to 5 inches) in length. The following morning at nine o'clock frost injury was evident. It appeared chiefly in the form of shiny, yellowish-brown, water-soaked spots which were slightly depressed and irregular in outline. The same symptoms were observed again on May 4, 1908,

the temperature having fallen to 31° F. during the night of April 30th and also during the night of May 3d. In all cases, the ultimate condition of the affected leaves is similar to that shown in Plate XVI.

TRUNK ROT, ? *Collybia velutipes* Curt. A large horse chestnut tree in Geneva languished for two or three years and finally died in the spring of 1903. Apparently, the death of the tree was due to a fungus rot of the trunk. The only fungus fruit bodies observed were sporophores of *Collybia velutipes*[93] which appeared in November, 1902, while the tree was still living. Several large clusters of sporophores broke through the bark on the south side of the trunk at a hight of one to two meters (3 to 6 feet). *C. velutipes* is usually saprophytic, but there are reasons for believing that it may be, sometimes, a wound parasite which was, seemingly, the case here. Hennings[94] states that *C. velutipes* occurs on living trunks of horse chestnut and several other kinds of trees.

IVY, BOSTON.

Ampelopsis tricuspidata.

LEAF-SPOT, *Phyllosticta labruscæ* Thüm. In general, the Boston ivy in New York is exceptionally free from disease, but it is occasionally affected with a leaf-spot due to *Phyllosticta labruscæ.* The Station herbarium contains specimens collected at Floral Park in July, 1902, and at Ossining in June, 1907.[95] Peck[96] has reported it from Menands, N. Y. Thirteen years ago Halsted[97] reported the same disease from New Jersey, using the name *Phyllosticta ampelopsidis* E. & M., which is now regarded as a synonym of *P. labruscæ.* It forms circular dead brown spots 2–7 mm. in diameter.

P. labruscæ is the pycnidial form of the grape black rot fungus *Guignardia bidwellii* (Ell.) Viala & Ravaz.

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93 Identified by G. F. Atkinson.
94 Hennings (61).
95 Host Herbarium Specimens Nos. 44 and 45.
96 Peck (101, p. 31).
97 Halsted (54, p. 410).

LILY, BLACKBERRY.

Belamcanda chinesis.

LEAF SPOT, *Heterosporium gracile* (Wallr.) Sacc. Some plants of the blackberry lily growing on the Station grounds in 1903 were severely attacked by this fungus during August. The upper portions of the leaves became brown and withered owing to the presence of numerous circular dead spots caused by the fungus.[98]

MAPLE, NORWAY.

Acer platanoides.

RAGGED LEAVES, *frost injury.* Each spring since 1903 the writer has made observations on the effect of late spring frosts on Norway maple foliage. The conclusion reached is that the raggedness of the early-formed leaves of Norway maple, occurring in New York more or less abundantly almost every season, is chiefly due to frost injury at time of leafing. We refer to the condition in which the leaves show numerous, irregular holes of various sizes. (Plate XIX.) In 1904 such injury was very common, owing to the frost which occurred on the night of May 10th, and it seems to have been the popular opinion that the holes were caused by some insect. This is not strange because the clean-cut, irregular holes closely resemble the work of biting insects.

Instead of being arranged in rows as on horse chestnut leaves (Plate XVI) the holes are distributed irregularly over the leaf. This difference is due to the differences in venation in the two kinds of leaves.

Norway maple buds usually open at about the same time as horse chestnut buds, which, at Geneva, is about May 1st. As with the horse chestnut, the time of leafing varies slightly with the season.[99] In the bud, the leaves are folded fan-fashion so

[98] Host Herbarium Specimen No. 46.

[99] In this connection it is interesting to note that, in 1909, horse chestnut leaves appeared about three days earlier than on the same tree in 1905; while Norway maple leaves appeared about five days *later* in 1909 than on the same tree in 1905. There can be no doubt as to the accuracy of these observations. Neither were there any inequalities of environment which

that the principal veins are on the outside and the parenchyma inside. Under a hand lens they appear to be thickly covered with glistening, roundish, translucent bodies. These are the heads of short-stalked, capitate plant hairs which constitute the sole protection of the unfolding leaves. They occur on the petioles and leaf blades; also, sparingly, on flower peduncles.

DROPPING OF LEAVES IN JUNE, *Aphids*. During the last week of June, 1903, Norway maples along the streets of Geneva dropped large numbers of their leaves. Under some trees they were so numerous that the ground was nearly hidden by them. A striking feature of the fallen leaves was their freedom from brown spots and blemishes. Although somewhat dry and papery they retained their green color for several days after falling. It seemed strange that such healthy-appearing leaves should fall.

However, the cause was not difficult to find. For some time previous the trees had been infested with aphids[1] which made their presence known by their honey dew. This made the leaves wet and sticky and spotted the walks beneath. While some trees infested by aphids were not dropping their leaves, the worst-infested trees dropped them most. Plainly, the aphids were the cause of the trouble. It was observed that they gathered in dense clusters around the base of the leaf petioles; also, the large veins appeared to be favorite feeding places for them.

In 1908, there was extensive dropping of Norway maple leaves from the same cause. In 1909, during a high wind on June

would account for the phenomenon. It seemed to be the general condition in 1909 that leafing was hastened in horse chestnut and retarded in Norway maple. To what extent such inversions in the relative order of leafing occur or how they are to be explained the writer does not know. Pfeffer (104, p. 212) states that "many of our flowers do not always bloom in the same order" and Prof. U. P. Hedrick, Horticulturist of this Station, informs us that certain varieties of plums do not always ripen in the same order. According to Jackson (65), Rahn has used the term "'phenological inversion" to designate "an abnormal inversion of the relative blossoming of plants, caused by meteorologic conditions." It seems to the writer that the same term may be applied, with propriety, to the cases of abnormal leafing and ripening here mentioned.

[1] The species was not, at the time, identified; but Mr. P. J. Parrott, the Station Entomologist, informs us that the aphid commonly infesting Norway maple leaves is *Chaitophorus aceris* Linn.

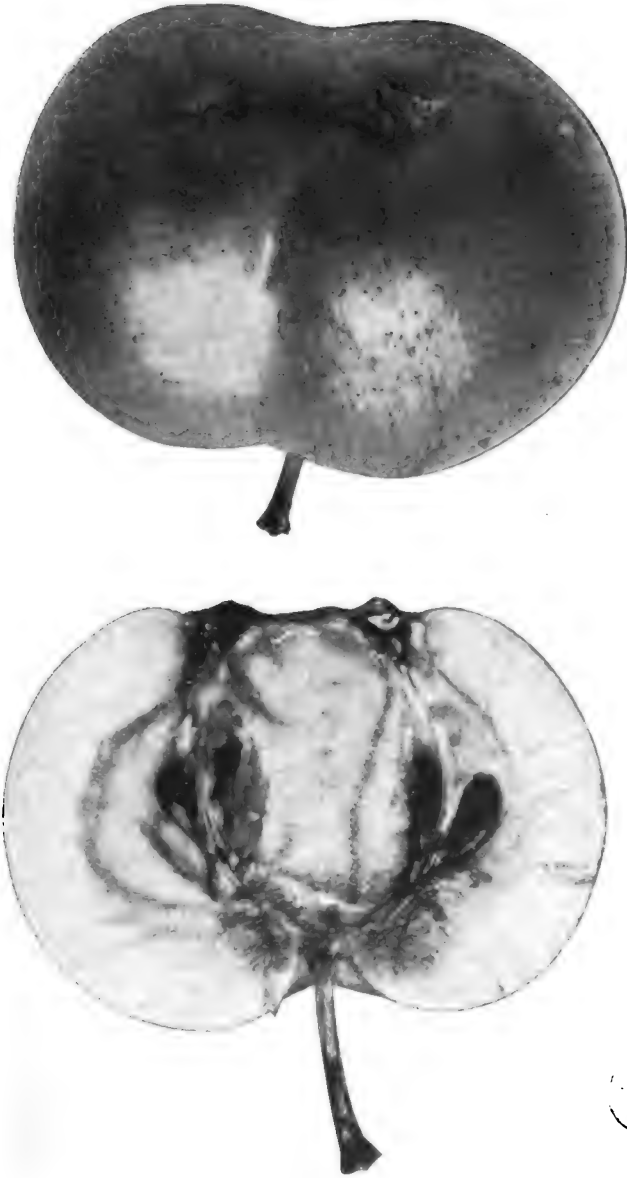

Plate X.— A Double Apple.
(Natural size.)

PLATE XI.— SPOROPHORES OF *Fomes fomentarius* ON PROSTRATE BEECH TRUNK.
(From photograph by B. M. Duggar.)

Plate XII.— Sporophores of *Fomes fomentarius* Which Changed Their Direction of Growth.

1. On top of log. (One-half natural size.)

2. On side of log. (Natural size.)

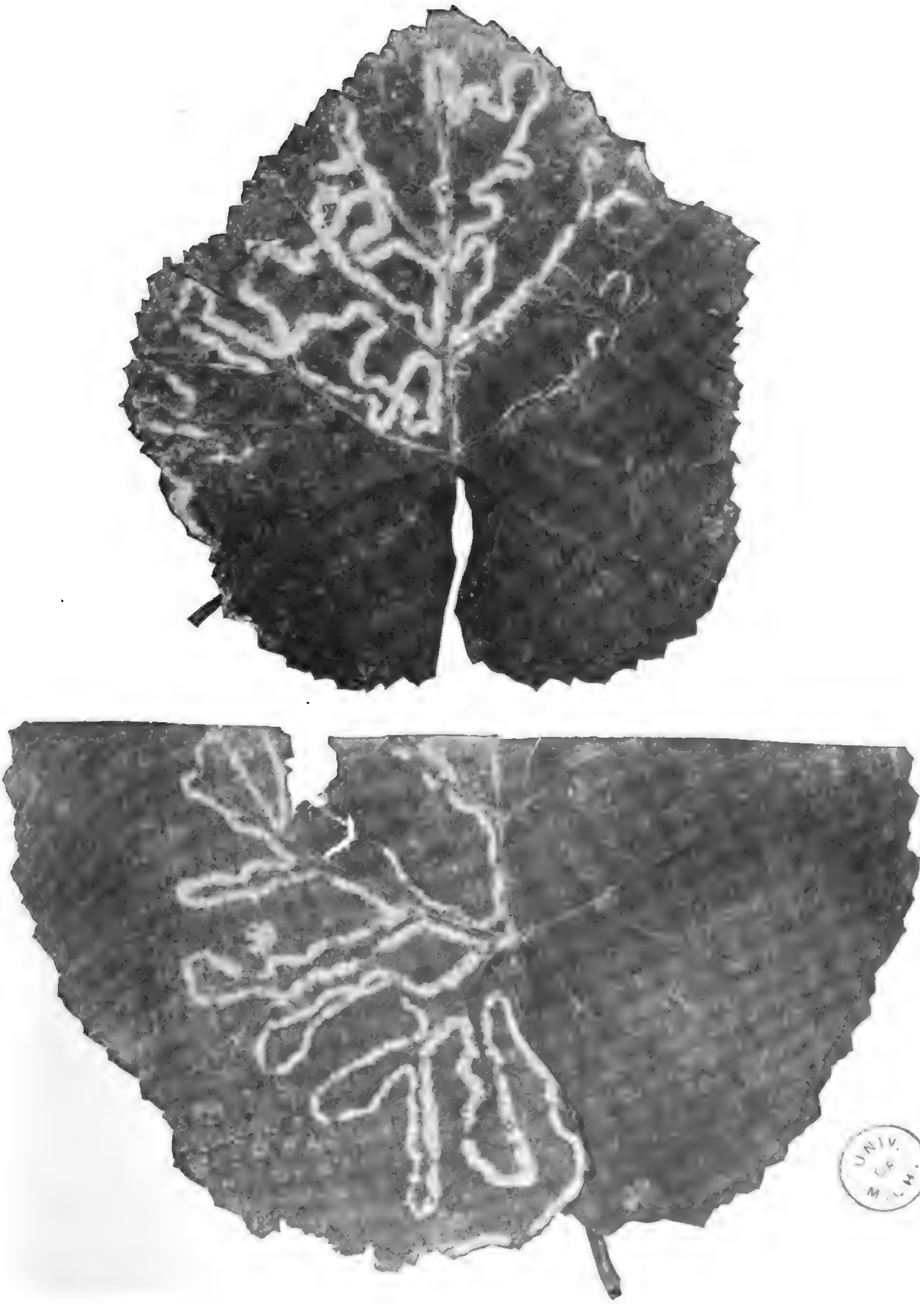

Plate XIII.—Grape Leaves With Powdery Mildew Growing Along the Path of a Leaf Miner.

(Natural size.)

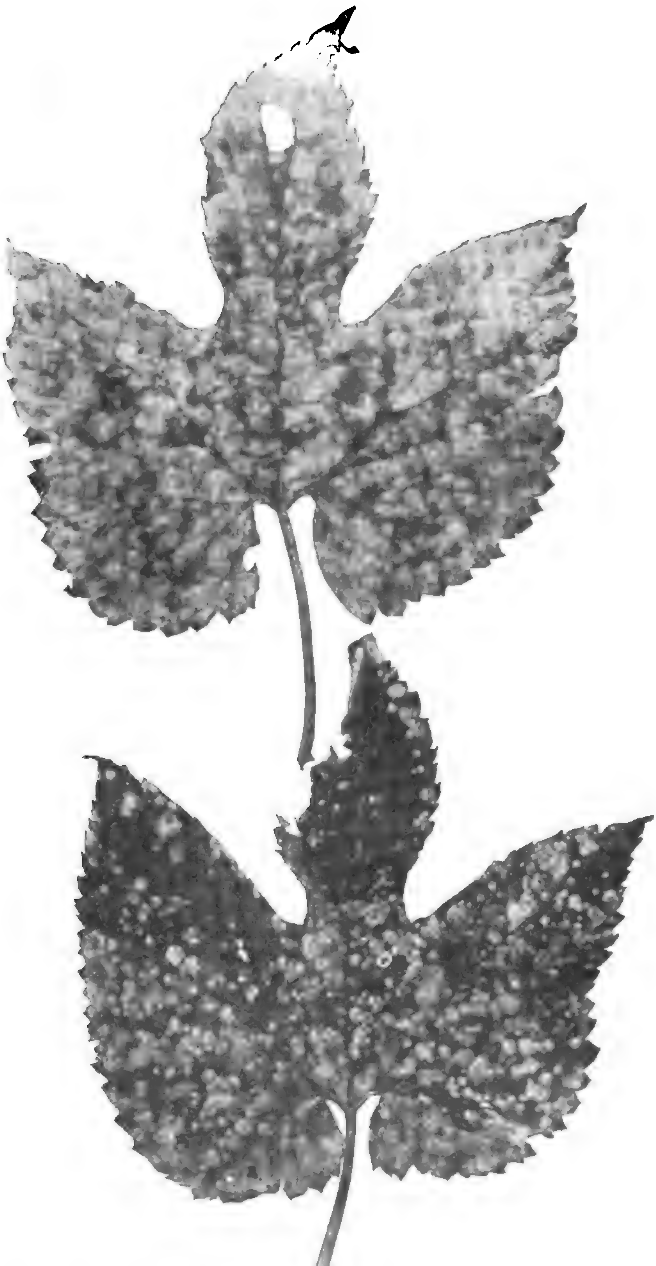

Plate XIV.— Hop Leaves Attacked by Powdery Mildew, *Sphærotheca humuli.*

PLATE XV.—CLUSTERS OF HOP CONES: 1, HEALTHY; 2, AFFECTED WITH POWDERY MILDEW.

PLATE XVI.— HORSE CHESTNUT LEAF INJURED BY SPRING FROST.
(One-half natural size.)

PLATE XVII.—AVERAGE CONDITION OF HORSE CHESTNUT BUDS APRIL [illegible].
1 and 2. Of trees on Station grounds. 3 and 4. Of an early leafing tree.
Difference, about [illegible] days.
Natural size.

Plate XVIII.— Partially Opened Buds of Horse Chestnut (1) and Norway Maple (2).

Light frost at this stage causes the ragged leaves shown in Plates XVI and XIX. (Natural size.)

PLATE XIX.—NORWAY MAPLE LEAVES INJURED BY SPRING FROST.
(Natural size.)

PLATE XX.— SPANGLE GALLS ON LEAVES OF WHITE OAK.
(Natural size.)

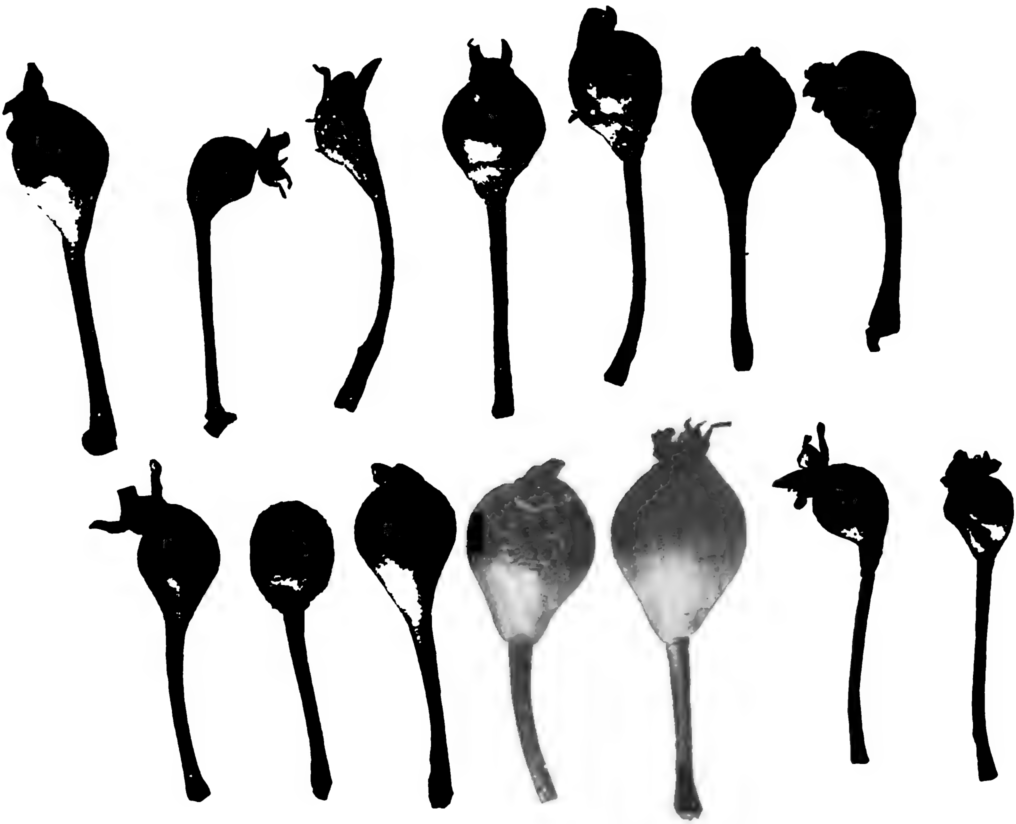

Plate XXI.— Fruits of Kieffer Pear Attacked by Rust.
One fruit (the largest one) healthy; all others diseased.
(Natural size.)

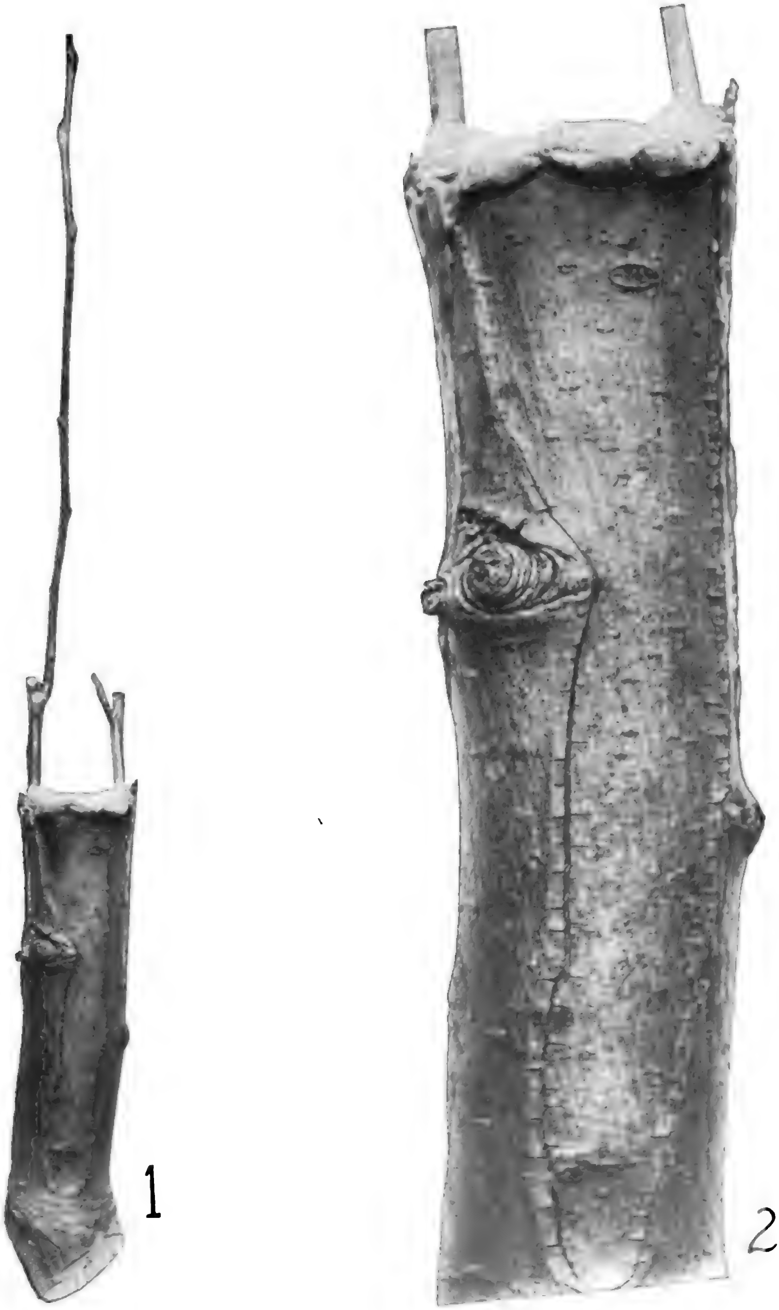

Plate XXII.— Sheldon Pear Stock With Yearling Seckel Cions.
One cion failed because of canker on that side of the stock.
(1. One-third natural size; 2. Same stock, natural size.)

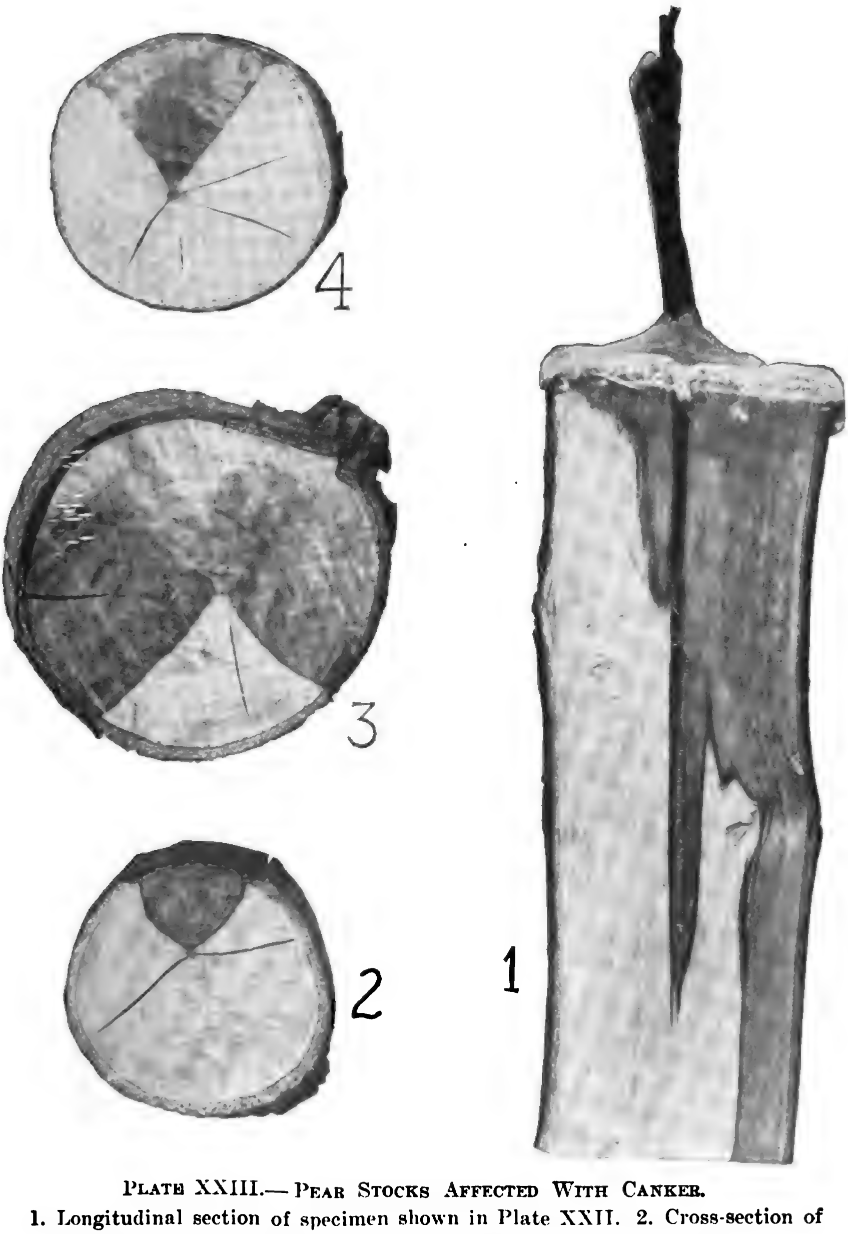

Plate XXIII.— Pear Stocks Affected With Canker.

1. Longitudinal section of specimen shown in Plate XXII. 2. Cross-section of same two inches from lower end of canker. 3 and 4. Cross-sections of other stocks. (All figures natural size.)

PLATE XXIV.—QUINCE RUST (1) AND RASPBERRY FUNGI.

2. Conidiophore and spore of *Botrytis patula* × 350.

3. Spores of *Coniothyrium fuckelii* × 850.

4. An ascus of *Leptosphæria coniothyrium* × 350.

5. Spores of *Leptosphæria coniothyrium* × 660.

6. Cross-section of diseased raspberry bark showing two perithecia of *Leptosphæria coniothyrium* (on the left) and two pycnidia of *Coniothyrium fuckelii* (on the right) × 65.

PLATE XXV.— A FASCIATED ROSE CANE.

PLATE XXVI.— TOMATO STEM NEARLY SEVERED BY TRANSVERSE CRACK, TWELVE INCHES BELOW THE TIP.

(One-half natural size.)

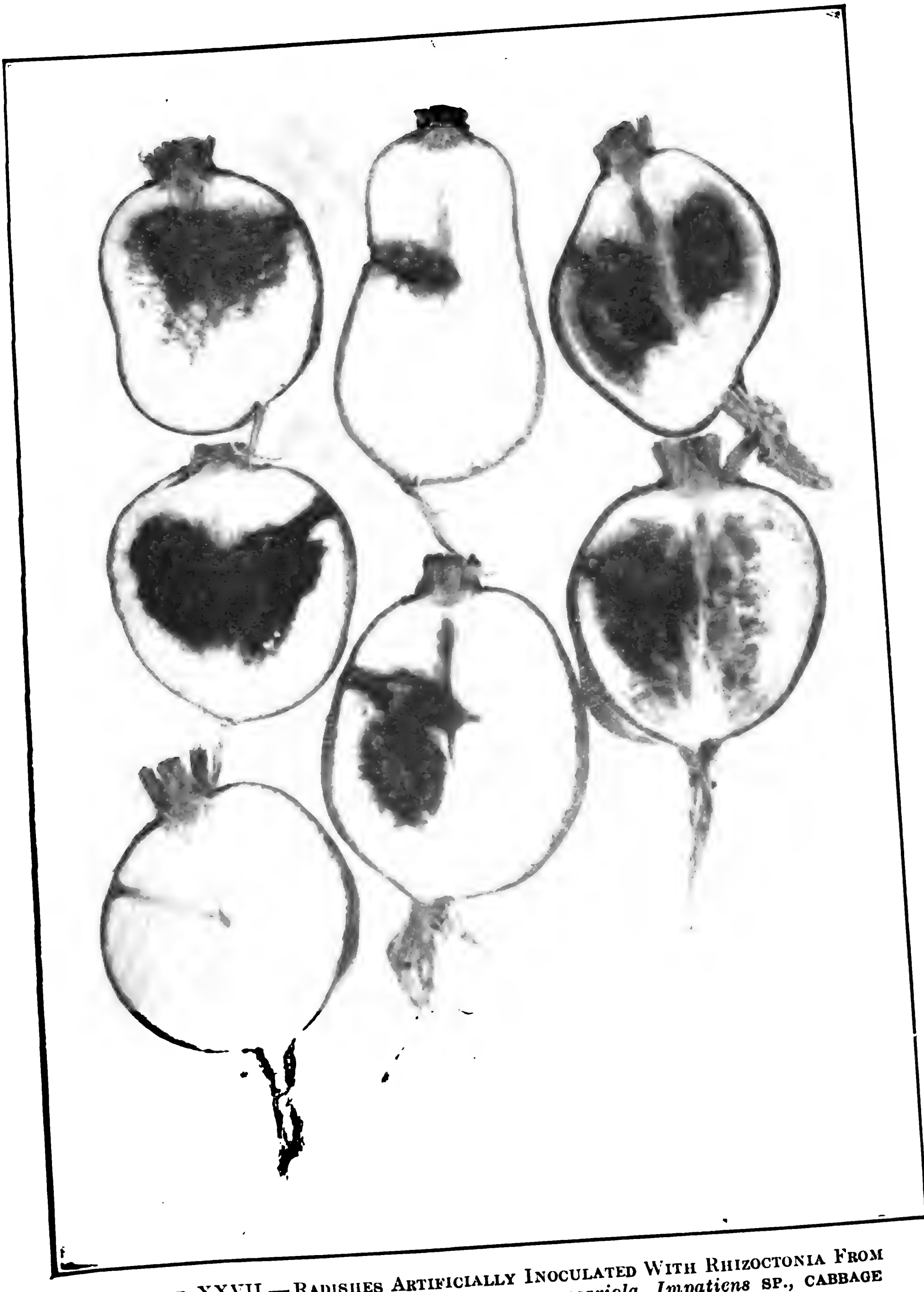

PLATE XXVII.—RADISHES ARTIFICIALLY INOCULATED WITH RHIZOCTONIA FROM CARNATION, *Actinidia polygama*, *Lactuca scariola*, *Impatiens* SP., CABBAGE AND LETTUCE. LOWER FIGURE AT LEFT, CHECK.

20th, so many Norway maple leaves fell that the attention of many people was directed to the phenomenon, particularly in Canandaigua. Apparently, it is a common trouble.

MAPLE, SILVER.

Acer saccharinum.

BLACK SPOT, *Rhytisma acerinum* (Pers.) Fr. Mycological literature contains numerous references to the occurrence of *Rhytisma acerinum* on the leaves of Norway maple, *Acer platanoides,* and sycamore maple, *A. pseudoplatanus.* Hartig[2] even says that *A. platanoides* suffers especially from this parasite, *A. pseudoplatanus* and *A. campestre* in less degree.

Our own observations indicate that, in New York, *A. platanoides* is rarely if ever attacked by Rhytisma. *A. saccharinum* and *A. rubrum* are the maples commonly affected here. On October 21, 1909, the writer drove along the north shore of Long Island from Cutchogue west to a point north of Riverhead, a distance of nine miles. Throughout almost the entire distance the highway is lined with maples of three species — *A. saccharinum, A. platanoides* and *A. pseudoplatanus.* Of the first two species named, there are numerous specimens, but of the third species only an occasional tree. The trees were scanned for Rhytisma, the characteristic tar-colored spots of which may be detected at a considerable distance. Every tree of *A. saccharinum* was more or less affected with *Rhytisma acerinum,* some of them quite severely; while not a trace of the fungus was observed on any tree of the other two species.

This disease is much more common on Long Island than in any other part of the State.

MUSKMELON.

Cucumis melo.

LEAF-SPOT, *Septoria cucurbitacearum* Sacc. About the middle of September, 1909, the writer found, in a garden at Fayette-

[2] Hartig (57, p. 98).

ville, some muskmeloon plants the leaves of which were considerably affected with a leaf-spot disease caused by *Septoria cucurbitacearum* Sacc.[3] At first sight, the spots appeared to be of two kinds; (1) small, gray or whitish spots .5–2.5 mm. in diameter; (2) large, brown spots 3–6 mm. in diameter. But microscopic examination showed that the two kinds of spots were caused by the same fungus. Both bore pycnidia of *Septoria cucurbitacearum* which appeared as minute black specks chiefly on the upper surface. Both kinds of spots were circular in outline, conspicuously visible on both surfaces of the leaf and frequently surrounded by a zone of yellowish-green color.

Apparently, this is an uncommon and probably unimportant disease of muskmelons. Its literature is meager. Although *S. cucurbitacearum* has been reported as occurring in this State on the living leaves of pumpkin[4] and on the fruit of squash,[5] the writer is unaware of any previous record of its occurrence on muskmelon leaves in New York. Davis has noted its occurrence on leaves of shaded muskmelon plants at Racine, Wisconsin, in 1890.[6] A later collection made by Davis at Racine in 1905 was distributed as No. 2171 of Ellis and Everhart's Fungi Columbiani. In 1905, Delacroix published an account of the disease stating that he had received specimens from many localities in France.[7]

Other species of Septoria recorded on Cucurbitaceæ are: *S. vestita* B. & C., on fruit of Cucurbita, spores 12 μ long; *S. citrulli* E. & E., on leaves of *Citrullus vulgaris* (watermelon), spores 10–25 μ long; and *S. sicyii* Pk., on leaves of *Sicyos angulatus* (burr cucumber), spores 40–60 μ long. In our specimens of *S. cucurbitacearum* the spores are 55–75 μ long and the pycnidia 85–120 μ in diameter.

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[3] Host Herbarium Specimen No. 47. Prof. H. H. Whetzel informs us that he, also, collected specimens of the disease near Syracuse in 1909 but in a different locality.

[4] Peck (92, p. 44).

[5] Peck (97, p. 118).

[6] Davis (24, p. 176). The date of collection is not given, but Dr. Davis informs us that it was Sept 12, 1890.

[7] Delacroix (25, pp. 168–170).

NASTURTIUM.

Tropæolum majus.

WHITE RUST, *Albugo candidus* (P.) Kze. On May 30, 1908, an Albugo, apparently *A. candidus,* was found on a few leaves of dwarf nasturtiums growing in two neighboring gardens in Geneva.[8] The sori formed circular white spots about 6 mm. in diameter on the under surface of the leaves. On the upper surface the location of the spots was marked by yellowish areas of indefinite outline. The globular, hyaline conidia measured 14–18 μ in diameter. No oöspores were observed.

It appears that this observation makes an addition to the already long list of host plants of *A. candidus.* At least *Tropæolum majus* is not included in Wilson's host-list which is supposed to be complete for North America.[9]

OAK, WHITE.

Quercus alba.

SPANGLE GALLS, *Cynips poculum* O. S. Although the insect troubles of plants do not properly come within the province of this bulletin, the following note on oak spangle galls is included for the information of plant pathologists who may be perplexed by them.

In August, 1900, Dr. S. A. Russell of Poughkeepsie sent us two oak leaves which were thickly covered, on the under surface, with peculiar saucer-shaped whitish bodies the nature of which we were at first unable to determine. On September 11, 1900, the writer, following directions given by Dr. Russell, visited the tree from which the specimens had been taken and made an examination of it. It was a magnificent white oak located at Clove, fifteen miles east of Poughkeepsie. It had a trunk four feet in diameter and a wide-spreading symmetrical top. Although almost every leaf bore large numbers of the saucer-shaped galls on the

[8] Host Herbarium Specimen No. 48.
[9] Wilson (165).

under surface, the general appearance of the foliage was but little out of the normal.

The galls are smooth, saucer-shaped bodies attached to the leaf by a short, slender foot-stalk.[10] It appears that they are at first flat and become saucer-shaped as they grow older. They are about two millimeters high and have a diameter of two to five millimeters. The margin of the saucer turns outward and a small conical elevation (marking the location of the larva) appears at the center. The color of the galls is white owing to a heavy bloom composed of short, rod-shaped bodies. When this bloom is removed some of the galls appear pink and others greenish. In general appearance the galls bear a striking resemblance to the apothecia of a Discomycetous fungus, but a microscopic examination quickly dispels the idea that they are fungus bodies. They have a cellular structure, a vascular system and contain an abundance of starch. In our observations only occasional larvæ were found and these were very small and immature. The galls are irregularly distributed on the under surface of the leaf exclusively. Sometimes several galls occur so close together that they crowd one another and become distorted. The leaf shown in Plate XX bore 154 galls, which is not an unusually large number. On the upper surface the affected portions of the leaf are somewhat yellowish and uneven owing to the presence of small pimples which mark the location of the galls.

Specimens of the galls were submitted to the late Prof. M. V. Slingerland of Cornell University, who reported concerning them as follows: "It is the work of *Cynips poculum* O. S. The galls are known as 'oak spangles.' See Fitch's Fifth Report on Insects of New York, Section 320; also, Monograph of Diptera of North America, Part I, page 201. In Beutenmüller's catalogue of gall-producing insects found within fifty miles of New York City (Bul. Am. Mus. Nat. Hist. 4: 245–278) the insect is called *Cecidomyia poculum* and the statement made that it has not been raised from the galls in this country. A student here

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[10] Host Herbarium Specimen No. 49.

[Miss Susan F. Howe] wrote her thesis on these oak galls and bred the flies, and they are a Cynips instead of a Cecidomyiid."

We are informed that this thesis has not been published.

OATS.

Avena sativa.

Blade blight, ? *Pseudomonas avenæ* Manns and *Bacillus avenæ* Manns. In 1906, 1907 and 1909 oats throughout New York State were quite generally affected by blade blight, which according to Manns, is caused by the associative action of the two species of bacteria named above.[11] The disease appears during June. The tips of the leaves become reddish or yellowish then turn brown and slowly wither and die. The affected plants are not killed outright, but their growth is checked.

June 2, 1909, a somewhat similar disease was prevalent in all oatfields in the vicinity of Riverhead, Long Island. The plants were then 8 to 12 inches high and the discoloration of the leaves extended backward from the tip for a distance of 3 to 5 inches. Many of the affected leaves showed irregular, water-soaked areas very suggestive of bacterial action. At this time there were no signs of such disease in central and western New York, but by the latter part of June the reddening of oats had become general.

Except in the case mentioned above we have never seen anything which would lead us to believe that this blade blight is a bacterial or fungus disease. On the contrary, the uniform distribution of the disease indicates that it is not contagious. The symptoms are rather those of defective nutrition caused by unfavorable weather conditions. The writer is inclined to doubt the accuracy of Manns' conclusions even though they seem to be supported by the results of his inoculation experiments. Possibly two distinct diseases have been confused.

[11] Manns (78).

· PEACH.

Prunus persica.

PREMATURE DROPPING OF LEAVES. The observations reported under this head were published eleven years ago in the Proceedings of the Eastern New York Horticultural Society. On account of the very limited circulation of these Proceedings it seems desirable to reproduce the article here. The writer has seen nothing of the kind since and has nothing to add concerning the cause of the strange phenomenon. The account is as follows:[12]

"On June 1, [1900] Mr. J. A. Hepworth, of Marlboro, called our attention to the fact that peach trees in that locality were dropping their leaves very freely. We visited several peach orchards and in all of them the leaves were dropping more or less. In some cases the ground under the trees was green with the fallen leaves. When the trees were jarred, clouds of leaves would fall. Not infrequently 10 to 15 per ct. of the leaves fell; and we saw a few trees which had probably lost as much as 20 per ct. of their leaves. Mr. Hepworth first noticed the trouble May 30.

"The fallen leaves were green and apparently normal except that on the margins there invariably occurred one or more dead brown spots. These spots were semi-circular, one-fourth to one-half inch across, generally situated on the margin from one-half to two-thirds of the distance toward the outer end of the leaf, rarely at the tip and never on the interior. Frequently, there were two spots situated on opposite margins of the leaf, sometimes only one and again 3 to 5 spots.[13] In color, the spots were at first reddish brown or bronze, but later light brown and dry. Often the spots showed a tendency to separate from the green tissue, but it was rare that they actually dropped out. The spots were to be found on leaves still on the tree and such leaves would fall with the slightest jar. There was no discoloration at the point where the petiole separated from the twig.

[12] Stewart (141).
[13] Host Herbarium Specimen No. 50.

"The drop was general on all varieties, on soil cultivated and uncultivated, fertilized and unfertilized, drained and undrained, on thrifty and unthrifty trees, and in exposed and protected situations. In one case we saw a young orchard not yet in bearing standing close beside an old orchard. No leaves were dropping from the young trees, while in the old orchard fully 15 per ct. of the leaves were on the ground.

"We do not know how widespread the dropping of peach leaves may have been. It was quite general in the vicinity of Marlboro, but did not occur farther up the Hudson at West Athens or Catskill, or anywhere in western New York so far as we can learn. Mr. John Gould, Aurora Station, O., informs us that a similar peach leaf-drop occurred in some parts of Ohio during the past season. It is very unusual for peaches to drop their leaves in this manner.

"There were no indications of the presence of any fungus on the spots. Certainly, the trouble was not of fungous origin. It was due to purely physiological causes; and we believe it was brought about by weather conditions; exactly what these conditions were we do not know.

"In seeking to account for the dropping of the leaves something besides the spots must be considered; because the spots were too few and too small to have caused (by themselves) the leaves to fall. And yet, if we could determine the cause of the spots it would probably be easy to account for the falling of the leaves, because the two phenomena evidently owe their origin to the same cause."

POWDERY MILDEW, *Sphærotheca pannosa* (Wallr.) Lév. ? The Station orchard contains 350 varieties of peaches, 50 of apricots and 33 of nectarines, planted from one to four years. The season of 1910 being a favorable one for peach powdery mildew it was thought a good opportunity to determine the relative susceptibility of the different varieties. Accordingly, on August 31 a tour of the orchard was made and affected varieties noted. Mildew was

found on only eight varieties of peaches and two varieties of nectarines[14] The peaches affected were: Bailey, Conkling (moderately), Tillotson, Simmons No. 1,[15] Wright, Morrell, Thomas Rivers and Illinois Peach. The affected nectarines were Early Newington and Hunt's Tawney.

On June 24, 1910, a fruit grower from Holley brought to the Station leaves, twigs and fruit of peach showing an abundant growth of powdery mildew. He said that the tree from which the specimens came was a seedling. This is exceptionally early for so severe an attack.

The writer has never seen perithecia of the peach powdery mildew.

PEAR.

Pyrus communis.

CRIMSON FOLIAGE. During the past few years a certain Kieffer pear orchard at Geneva has behaved in an interesting manner. The orchard contains 60 trees in four rows of 15 trees each. The rows run north and south. The north end of the orchard is on a hillside while in the southern portion the land slopes just enough to give good surface drainage. The trees on the hillside are much larger, thriftier and more productive than those in the lower part of the orchard. The unthriftiness of the trees on the low land is probably due, chiefly, to an excess of water in the soil.

The interesting feature of the orchard is the coloration of the foliage in autumn. During October the leaves on most of the trees on the low land become brilliantly colored (a shade of red) while those on the hillside show but little if any such color. In 1906 and 1907 the contrast was particularly striking. By November 4, 1906, the trees on the low land (with one exception) had dropped most of their leaves, which had been brilliantly colored for about a month; while the 24 trees on the hillside held practi-

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14 As some of these varieties have not fruited it is not known that they are true to name.

15 This is a temporary name given a seedling.

cally all of their leaves and they were still green. In 1907 the trees on the low land (with two exceptions) were moderately colored from about October 1 to October 20. Then there came a hard frost and immediately afterward the foliage became very brilliantly colored. A few days later there was another hard frost which caused the colored leaves to blacken and fall. By November 1 the trees were bare of leaves. But the trees on the hillside were still in full foliage as late as November 10. About November 1 they began to change their color from green to a shade of yellow. On November 10 yellow was the dominant color, but there was a little red mixed with it.

In 1906 one tree on the low land behaved like the trees on the hillside. This tree was considerably larger and thriftier than its neighbors. In 1907 *two* trees kept their leaves green and held them late like the trees on the hillside. One of these was the exception of 1906, but the other was a small unthrifty tree standing next to it.

At times this orchard has been used for a chicken run and the chicken house being at the north end it is likely that the trees in that part of the orchard have received more nitrogen which probably accounts, in part, for their greener foliage and greater thriftiness.

However this may be, it is plain that crimson foliage on pear trees is a sign of unthriftiness. The specific causes of the unthriftiness may be various — poor underdrainage, insufficient plant food, a diseased condition of the trunk or roots, winter injury, drought injury, etc.

Œdema. Early in March, 1910, one of the large nursery companies of Rochester called our attention to a peculiar trouble affecting pear trees in their store house. On March 14 the writer visited the store house for the purpose of investigating the trouble and found the trees affected as follows: On the trunk around the bases of the branches, also around scars where branches had been cut off the previous fall before the trees were placed in storage

and even at the "union" (the point where cion and stock unite) the bark had loosened and cracked exposing loose-celled greenish-white œdematous tissue. In the handling of the trees incident to packing this loosened bark often rubbed off and upon exposure to dry air the thin-walled cells of the white tissue quickly collapsed and turned black. Accordingly, when unpacked by the planter, the trees presented a bad appearance. The store house contained large quantities of pear trees of many varieties all of which were more or less affected. The Sheldon was more affected, perhaps, than any other variety, but some of the dwarf varieties were nearly as bad. Trees of apple, peach, plum and cherry stored in the same house under parallel conditions were unaffected.

A member of the nursery company stated that they had been storing pear trees for 15 years past and never before had any such trouble. Out of 25 leading New York nurserymen with whom we have corresponded on this subject only three have ever seen the trouble. One from Niagara County writes as follows: "Some years ago we had considerable stock with similar injury. At that time we stored in a new cellar which was rather moist and warm and we always thought it was caused by excessive moisture and heat. Cions very often take on the same condition when held late especially if moist and warm." Another nurseryman, from Dansville, writes as follows: "Since 1876 I have observed that the rapid growing pears have shown the condition mentioned. Except in isolated individuals no harm has appeared. In bad cases, showing in the autumn over a surface of two inches square, the tree if left in the nursery row will show winter injury. This condition also obtains in rapidly grown apple trees like King and Baldwin." The third is a Fredonia nurseryman who has observed it, but never lost any trees on account of it. On May 3, 1897, this gentleman sent us a specimen accompanied by the following letter: "By this mail I send you a section of a Duchess d'Angouleme standard pear tree on which the bark split open much in the same way as pop-corn splits when roasted.

They did this during the winter in the nursery cellar. I had the same thing occur once before on dwarf trees, but only on the Duchess; no other variety was so affected." This is the only instance of pear œdema coming under our observation prior to the Rochester case.

The loss on the pear trees being considerable the nursery company wished to learn the cause of the trouble in order that a recurrence of it might be avoided. A very brief examination sufficed to convince us that it was not caused by an organism of any kind — fungus, bacterium or insect. It was plainly a physiological disorder known as œdema. In growing plants, œdema is believed to be due to an excess of water in the tissues which causes the cells to become abnormally distended. Such accumulation of water is favored by wet soil and high temperature coupled with high humidity and insufficient light.[16]

Naturally, the cause of such a severe case of an unusual trouble is to be sought in some unusual conditions surrounding the trees. The most notable and unusual feature of the season of 1909 was the severe drought in the fall; but œdema would not be favored by drought. Moreover, it does not seem that the weather can have had anything to do with it because other nurserymen growing pear trees in the same locality had no such trouble. So far as can be learned the trees were not subjected to any unusual methods of culture and the matter of soil seems to be eliminated by the fact that the trees were grown in three different localities. Likewise, there seems to have been nothing unusual in the management of the storehouse. A daily record was kept of the maximum and minimum temperature and humidity of the air in the store house. According to this record, the temperature and humidity of the store house during the winter of 1909–10 were practically the same as in previous years. This is shown in the accompanying table:

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[16] See Atkinson (7 and 8) and Sorauer (134, p. 337).

TABLE I. TEMPERATURE AND HUMIDITY IN NURSERY STORE HOUSE.

MONTH AND YEAR	Humidity			Temperature					
				Minimum			Maximum		
	Lowest	Highest	Average	Lowest	Highest	Average	Lowest	Highest	Average
	Per ct.	*Per ct.*	*Per ct.*	*Deg. F*	*Deg. F*	*Deg. F*	*Deg. F*	*Deg. F*	*Deg. F*
December, 1907...	80	82	81.8	34	43	37.1	35	45	39.1
1908...	79	82	80.9	33	48	35.1	35	50	37.6
1909...	77	79	78.7	33	38	35.7	35	40	37.5
January, 1908...	80	82	81.6	33	37	34.5	34	38	35.5
1909...	78	82	80.1	33	40	34.7	34	44	36.9
1910...	77	81	79.2	33	37	34.7	35	38	36.5
February, 1908...	82	82	82.0	33	38	34.3	34	39	35.3
1909...	78	80	79.2	33	36	34.1	34	39	35.2
1910...	80	81	80.1	33	35	34.2	34	37	35.5

The store house is a large one, built entirely above ground and well lighted by means of skylights. The trees are piled in long double ricks with the tops inside and the roots exposed. These double ricks are about sixteen feet high and separated by passages six feet wide. When the humidity falls below the desired point the roots of the trees are sprayed with water. When the temperature gets too high the ventilators are opened.

In order to determine what the after effects of the œdema might be, twelve badly affected trees were planted on the Station grounds and kept under observation until the following winter. This lot of trees contained two Clapp's Favorite, two dwarf Bartlett, two dwarf Wilder, two dwarf Louise Bonne de Jersey and four Sheldon. The Louise Bonne de Jersey and Sheldon trees were three years old, the others two years old. The four Sheldon trees were affected only around the bases of the branches, but on all the others the œdema occurred also at the "union."

One dwarf Wilder and one Sheldon tree started slowly, but all of the others apparently made a normal growth. At an exami-

nation made in October it was found that only a few of the affected branches had died. In most cases the wounds made by the œdema had healed leaving merely a ring of rough bark around the base of the branch. This experiment shows that the affected trees were but slightly, if at all, injured for planting.

While this pear trouble is clearly a case of œdema we are unable to explain how it was brought about or how its recurrence may be prevented.

Rust, *Gymnosporangium globosum* Farl.[17] Mr. F. A. Sirrine, Riverhead, Long Island, has a Kieffer[18] pear orchard of 150 trees set in the spring of 1903. On three sides it is bordered by thickets of red cedar. Each year since the trees were planted they have been more or less affected with rust. Prior to 1910 only the leaves were affected; but in the season of 1910 both fruit and leaves were severely attacked. On every tree almost every leaf showed numerous rust spots and many fruits were affected. Yet the damage was not great. Mr. Sirrine reports that the trees held most of their foliage until late in the fall, but some of the worst-affected leaves fell during August. Affected fruits were worthless, but as the fruit needed thinning they were not missed.

The following observations were made on June 15: Viewed from the upper surface the leaf spots were dark brown or nearly black with a conspicuous red border.[19] On the under surface they were of the same dark color, but the red border was lacking. Only the larger spots showed æcia which were commonly on the under surface though occasionally on the upper surface and, sometimes, also on the petioles.[20] Frequently, the rust spots were arranged in two irregular rows — one on each side of the midrib — as if imfection had occurred before the leaves were unfolded. The affected fruits, although still on the trees, were usually less than

[17] Identified by F. D. Kern.

[18] The Kieffer pear is a hybrid between *Pyrus communis* and *P. sinensis* (Bailey, Cyc. Am. Hort. p. 1471).

[19] On June 1, 1904, when the rust spots of that season were just beginning to appear the great majority were bright yellow and of pinhead size. Only a few (the larger ones) had reddish borders.

[20] Host Herbarium Specimen No. 51.

half normal size. Frequently, they were no larger than peas while normal fruits at this time were an inch long and three-fourths of an inch in diameter. (Plate XXI.) They were almost invariably misshapen. While the point of attack might be on any part of the fruit it was commonly near the base where there was a circular, flattened, black area devoid of æcia. However, there were to be found, here and there, affected fruits showing an abundance of well developed æcia.[21]

Proximity to the cedars appeared to make little difference in the amount of the rust. Trees 15 or 20 rods distant were quite as much affected as those standing within 20 feet of the cedars.

Mr. Sirrine informs us that this orchard was sprayed with bordeaux mixture while the trees were in full bloom. Had the spraying been done just after blooming it might have been more effective since the infection, at least on the fruit, must have occurred after blooming.

In the affected Kieffer orchard there were five trees of Worden and a row of Duchess on dwarf stock. No trace of rust could be found on either the fruit or leaves of the Duchess. The foliage of Worden, also, was free from rust, but many fruits of this variety were affected and a few showed well developed æcia.

Mr. Sirrine has another pear orchard surrounded on all sides by the same kind of red cedar thickets. This orchard was planted in the spring of 1909. Most of the trees are of the varieties Bartlett and Bosc. Not a trace of rust could be found here.

This rust of pears is a rare disease in New York. Besides the Long Island orchard above mentioned we have observed it in only two other localities, viz., at Milton and Athens where the foliage of Kieffer pears was sparingly affected in 1901. Thaxter[22] reported the same rust on the leaves of Kieffer pears in Connecticut twenty years ago.

FAILURE OF GRAFTS, ? *Sphæropsis malorum* Berk. During the past few years a pear grower of Kendaia who has done considerable grafting in his orchard has had trouble with a disease which causes

[21] Museum Specimen No. 137 and Host Herbarium Specimen No. 52.
[22] Thaxter (154, p. 98).

the failure of the grafts by killing the end of the stock in which the cions are set.[23] Of the grafts made in the spring of 1908 about one-half failed from this cause. The trees used as stocks have been of several varieties, chiefly Sheldon, Bartlett, Anjou and Kieffer, and the trouble has appeared on them all. In the spring of 1909 the cions used were mostly of the variety Seckel. Many of the cions did not even start to grow. Others made a fair growth and were still alive in the spring of 1910, but were worthless because the end of the stock in which they stood was so badly cankered near the top that there never could be a good union between the cion and the stock. In April affected stocks appear as follows: Extending backward from the wax-covered end of the stock a distance of one to twelve inches the bark is dead and the wood beneath discolored. In some cases the whole upper part of the stock is affected; in others, a strip of dead bark extends down one side of the stock while on the other side the bark is normal. (Plate XXII.) The dead bark clings tightly to the wood. The affected area is bounded by a narrow crack which separates it sharply from the living bark adjacent. Almost invariably the brown discoloration of the wood extends clear to the pith, so that a stock having a narrow diseased strip on one side, shows, in cross-section, a V-shaped area which is frequently bounded by a narrow black line. (Plate XXIII, figs. 2, 3 and 4.) When the diseased area completely surrounds the upper end of the stock the cions do not start. When there is a strip of live bark on one side of the stock the cion on that side grows. No instance was observed in which the cion had started to grow and afterward died. This indicates that the disease started early and ran its course quickly. However, many of the cankers show evidence of two periods of activity. Whether these two periods occurred in the same season or in successive seasons was not determined.

Apparently, infection occurs at the time of grafting. Certainly, the disease does not enter through the cion but through the wound made in grafting. The lesions resemble those caused by the fire

[23] Museum Specimen No. 112.

blight organism, *Bacillus amylovorus*, but it seems improbable that it is a case of fire blight. There has been very little fire blight in the orchard for several years. Besides, it is somewhat difficult to infect mature wood with *Bacillus amylovorus*.[24] Suspicion points rather to *Sphæropsis malorum* as the cause. Pycnidia of this fungus were plentiful on the dead bark and sometimes, also, on the dead cions. Sphæropsis cankers on pear branches are of frequent occurrence in nature and Paddock's experiments demonstrated that such cankers may be produced by artificial inoculation.[25] Opposed to this theory is the fact that *S. malorum* is a very common fungus, whereas the graft trouble seems to be rare.

Whatever the causal organism, disinfection of the cut end of the stock before the covering of wax is applied should prevent the trouble. Probably the best method of disinfection would be by the use of a sponge saturated with a 1–1000 solution of corrosive sublimate.

PELARGONIUM, IVY-LEAVED.

Pelargonium peltatum.

ŒDEMA. On December 10, 1909, there came to our attention a case of œdema on pelargonium leaves in a greenhouse at Batavia. The plants were rooted cuttings just commencing vigorous growth. They were still in sand in the cutting bench. The air inside the greenhouse was kept rather warm and very moist. A considerable number of the leaves showed œdema, but the trouble was not sufficiently abundant to cause material damage. The disease manifested itself in the form of pimple-like elevations of two kinds: (1) Smooth, shiny ones having a water-soaked appearance; (2) irregular, gray, rough-topped ones. Both kinds of pimples occurred on both surfaces of the leaves, but were much more numerous on the under surface. Halsted[26] has noted the occurrence of this disease in New Jersey. According to Ward it may be expected to appear at any period of growth if the plants are over watered under high temperature.[27]

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[24] Arthur (4, p. 273).
[25] Paddock, (86).
[26] Halsted (51, p. 432).
[27] Ward (160).

PHLOX.

Phlox sp.

POWDERY MILDEW, *Erysiphe cichoracearum* DC. This is a common and often destructive disease of cultivated phlox. During the past ten years the Station has received numerous complaints of its ravages. It was observed to be very destructive at Queens in August, 1902, and at Riverhead in October, 1909.[28] The leaves and stems become thickly covered with a dirty-white mildew. In severe attacks the lower leaves fall prematurely. Perithecia are formed in great abundance on both leaf surfaces and also on the stems.

LEAF-SPOT, *Cercospora phlogina* Peck in MS. Specimens of a Cercospora on cultivated Phlox collected by the writer at Floral Park, June 28, 1900, were referred recently to Prof. C. H. Peck, State Botanist, who writes as follows concerning them: "I have examined the specimens of Cercospora on Phlox leaves, and think, like you, that it disagrees too much from the description of *C. omphacodes* to be lumped in with it, though its spores come near an agreement. It may be a variety, but I prefer to consider it a distinct species. I do not find any other Cercospora than *C. omphacodes* credited to Phlox so call your specimen *Cercospora phlogina* n. sp."

The fungus forms circular brown spots, usually 5 to 10 mm. in diameter, and conspicuous on both sides of the leaf. On the under surface the spots are of fairly uniform brown color all over, but on the upper surface they have a wide, dark brown border surrounding a lighter colored central portion.[29]

The brown spots were very numerous indicating that under favorable conditions the disease might become of economic importance.

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[28] Host Herbarium Specimens No. 53 and 54.
[29] Host Herbarium Specimen No. 55.

PLUM.
Prunus spp.

FUNGI ON BLACK KNOT, *Tricothecium roseum* (Bull.) Link and *Sporotrichum parasiticum* Pk. The black knot excrescences (caused by *Plowrightia morbosa*) on plum branches are frequently overgrown by *Tricothecium roseum* which forms a thin coating of pale salmon color. The spores of the fungus are nearly hyaline, pear-shaped and two celled. In a large orchard of German prunes near Geneva most of the trees were ruined by a severe attack of black knot. In the autumn of 1909 a majority of the knots in this orchard were quite thickly covered with *Tricothecium roseum*.[30] The fungus is considered to be only a saprophyte.

In October, 1909, the black knots on some neglected plum trees (*Prunus domestica*) at Seneca Castle were found to be covered with a whitish growth of *Sporotrichum parasiticum* Pk.[31] The shape of the hyaline, non-septate spores is described as elliptical,[32] but in these specimens many of the spores were distinctly fusoid.[33] Peck states that when the Sporotrichum occurs on young knots it apparently prevents the free formation of the Plowrightia perithecia.

TWIG BLIGHT AND CANKER, *Sclerotinia fructigena* (Pers.) Schrt. It does not appear to be generally known to fruit growers that plum twigs are frequently killed by the fruit-rot fungus, *Sclerotinia fructigena*. Severe attacks of fruit rot are usually accompanied by the dying of some of the smaller branches. Sometimes such trouble becomes conspicuous and attracts attention. A case of this kind occurred in orchards of Japanese plums (*Prunus triflora*) at Milton in 1901. On some trees fully one-third of the foliage was dead and brown. Upright-growing varieties, like Red June and Wickson, were most affected. In most cases the dead twigs were covered with the Monilia stage of the fruit-rot fungus

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30 Museum Specimen No. 138.
31 Identified by C. H. Peck.
32 Peck (95, p. 82).
33 Host Herbarium Specimen No. 56 and Museum Specimen No. 139.

and often there was an exudation of gum at the boundary between the living and dead wood.

A particularly interesting case of Sclerotinia twig blight occurred in a Geneva nursery in 1910. The affected trees were of the variety Compass which is said to be a hybrid produced from seed of the sand cherry (*Prunus besseyi*) fertilized by Miner plum (*Prunus hortulana*).[34] It is considered an exceptionally hardy variety. The trouble occurred in a block of about 3000 trees budded in the season of 1908. On May 24, 1910, almost every tree was more or less affected. On many trees the whole top was conspicuously browned. At this time the new shoots were two to four inches long. Many of them were dead and brown. Most of the trouble occurred in the upper part of the tree — the uppermost 12 to 15 inches — but here and there dead shoots were found lower down. Healthy and dead shoots were intermingled. Some of the shoots were just wilting; others were brown and dry. Most of the dead shoots were covered with a luxuriant growth of Monilia at the base and frequently there was an exudation of gum at this point. The trees had bloomed freely and the blossoms had been blasted by Monilia. The shriveled, Monilia-covered flower clusters were still to be seen in the axils of the twigs. It was plain that the twigs had been attacked at the base. There were many which were dead at the base while only wilted at the top. The fungus had gone in by way of the blossoms, not through the tip of the shoot. On both sides of the affected block of trees were several thousand plum trees of various Japanese and *Prunus domestica* varieties all entirely free from the disease; but none of these had bloomed.

In another part of the same nursery a block of 10,000 plum trees of the same age and variety were similarly affected. Here, an adjacent block of the variety Wild Goose (*Prunus munsoniana*) showed a little of the trouble and it was found that every dead twig had a cluster of dead blossoms in the axil. Also, on a few rows of double flowering almond (*Prunus japonica*), nearby, the shoots were killed back 12 or 14 inches by Monilia.

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[34] Little (72).

Sometime during June the diseased tops of the Compass trees were cut away. The result was that by the middle of September the trees appeared healthy and thrifty, but upon closer examination it was found that a majority of the trees had cankers on the trunk. These cankers were one to two inches long. Frequently, the wood was laid bare and there was a copious exudation of gum. A small dead twig at the center of each canker plainly indicated that it had its origin in the Monilia attack.

POPPY MALLOW.

Callirhoë involucrata.

RUST, *Æcidium tuberculatum* E. & K. Specimens of this were collected by F. H. Blodgett on June 16, 1899, at Floral Park where it was abundant and destructive. Plants severely attacked produce dense clusters of short, upright shoots, while on healthy plants the branches are procumbent.[35] Only the æcial form of this fungus is known. Carleton has suggested that it is perennial within the tissues of its host and so does not require an alternate form for its perpetuation.[36]

POTATO.

Solanum tuberosum.

RHIZOCTONIA. Rolfs holds that a species of Rhizoctonia, which he has shown to be connected with *Corticium vagum* B. & C. var. *solani* Burt, is responsible for extensive potato failures in Colorado,[37] and Selby ascribes a destructive "rosette" disease of potatoes in Ohio to the same fungus.[38] What appears to be the same species of Rhizoctonia occurs very abundantly on the tubers and underground stems of potatoes in New York,[39] yet we have seen only a few instances in which the plants seemed to be materially injured by it. We consider Rhizoctonia a comparatively unim-

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35 Host Herbarium Specimen No. 57.
36 Carleton (17; 18, p. 27).
37 Rolfs (109 and 110).
38 Selby (125 and 126).
39 Duggar and Stewart (29, pp. 17–22).

portant disease of potatoes in New York except, possibly, on Long Island.

In 1904 we planted two rows with Rhizoctonia-infested tubers. Previous to planting, the tubers used in one of the rows were disinfected by soaking them two hours in a solution containing one pint of formalin in thirty gallons of water. The resultant plants on both rows were healthy. There were no indications of rosette and none of the plants died prematurely. The two rows gave the same yield, viz., 377 pounds or at the rate of 314 bushels per acre. Certainly, the Rhizoctonia was not very harmful in this case. However, it should be stated that the crop, even on the row planted with untreated seed, was but little infested with Rhizoctonia. The soil conditions may have been unfavorable to the fungus.

On June 17, 1910, the writer saw, for the first time, fresh specimens of *Corticium vagum* var. *solani* on living potato stems. It was at Orient, Long Island. Many potato fields in eastern Long Island were in poor condition at this time. There were many undersized, sickly-looking plants with small, curled leaves which were sometimes green and sometimes yellowish. While endeavoring to determine the cause of this trouble it was observed that the stems of some of the affected plants were coated with a bluish-gray, mealy fungus which extended from the surface of the soil to a hight of one to three inches, sometimes enveloping also the lower leaves. Upon microscopic examination the fungus proved to be *Corticium vagum* var. *solani*. The following day the same fungus was found on many plants in several potato fields at Riverhead. In the great majority of cases the plants showing Corticium were sickly ones, but occasionally it occurred on large, thrifty plants. While the Corticium seemed to prefer stunted plants, it was by no means clear that the fungus was responsible for their unhealthy condition. On many of the Corticium-infested plants it was impossible to find any lesions on the stem, either above or below ground; the roots appeared normal and the seed piece was still sound. The portion of the stem covered by the Corticium was in no way injured by it. The fungus was entirely superficial and could be readily washed or rubbed off. The plants on which it was found were 6

to 12 inches high. Its appearance had been preceded by a period of wet, foggy weather.

Some mycologists regard *Rhizoctonia violacea* Tul. synonymous with *R. solani* Kühn.[40] On this point the writer does not care to express an opinion. The purpose of this note is to show that the Rhizoctonia of potatoes in Colorado and New York is not *R. violacea.* In the first place, there is a marked difference in color — the potato Rhizoctonia is brown while *R. violacea* on alfalfa roots is readily identified by its violet color. Secondly, the potato Rhizoctonia is abundant in the potato fields of New York and Colorado while, so far as we know, *R. violacea* has never been collected on alfalfa roots in either of these states. Experience has shown that, in New York, at least, Rhizoctonia-infested potato fields may be seeded to alfalfa with safety. The writer is confident that the potato Rhizoctonia of New York is identical with the potato Rhizoctonia of Colorado, but it is entirely different from *R. violacea* on alfalfa.

QUINCE.
Cydonia vulgaris.

RUST, *Gymnosporangium clavipes* C. & P.[41] During the summer of 1910 quinces throughout western New York were quite generally attacked by rust. It was observed, also, at Milton in the Hudson valley. The disease was more common than at any previous time since 1897. Both twigs and fruit were affected. On twigs the point of attack was commonly at the base of new shoots. Affected fruits were very conspicuous during July and August. They were covered, either wholly or in part, by masses of orange-yellow æcia, the long peridia of which often gave the fruit a woolly appearance. (Plate XXIV, fig. 1.)[42] Some fruits were attached at the stem end, others at the calyx end, and usually the affected fruits were much distorted and entirely worthless. In many cases no red cedar trees were to be found anywhere in the vicinity of the affected quince orchards.

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[40] Saccardo (115, 14:1175); Güssow (47).
[41] Identified by F. D. Kern.
[42] Host Herbarium Specimens Nos. 58 and 59.

RADISH.

Raphanus sativus.

Damping off, *Rhizoctonia* sp.[43] A number of radish beds in an Irondequoit greenhouse inspected during January, 1910, were observed to contain circular spots from a few inches to a foot or more in diameter in which the plants were dying. A number of the diseased plants, at various stages of growth, were collected and brought to the Station. A microscopic examination showed that all were affected with the fungus, Rhizoctonia. Observation indicates that infection takes place first at the level of the soil causing the leaves to have a wilted, drooping appearance. From this point the disease spreads into the leaves and root of the plant, soon causing its death. On mature radishes decayed spots of irregular shape are produced and at an advanced stage the diseased portions of the plant are covered with a white felted mycelium.

This radish disease has been described, previously, in Bulletin 186 of this Station.[44] It has also been illustrated by Duggar.[45] The causal fungus produces spores but rarely, if at all, and therefore can be transferred from place to place only by diseased plants or infected soil. The experience of growers has shown conclusively that it can be effectively controlled by steam sterilization of the soil.

Some cross-inoculation experiments made by Mr. Stewart in 1902 indicate that radishes are susceptible to attack by Rhizoctonia occurring on several species of host plants. Radishes were artificially inoculated with pure cultures of Rhizoctonia from carnation, *Actinidia polygama, Lactuca scariola, Impatiens* sp., cabbage and lettuce. Pronounced cases of rot resulted from all of the inoculations, while check plants remained perfectly sound to the end of the experiment. (Plate XXVII.)

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[43] By S. M. McMurran.
[44] Duggar and Stewart (29, p. 22).
[45] Duggar (28, p. 446).

RASPBERRY.

Rubus spp.

CANE BLIGHT, *Leptosphæria coniothyrium* (Fckl.) Sacc. In an earlier publication of this Station the writer described a destructive disease of raspberry canes caused by a fungus which was doubtfully referred to *Coniothyrium fuckelii* Sacc.[46] Subsequently, it was observed that, in spring, a pyrenomycetous fungus, *Leptosphæria coniothyrium* (Fckl.) Sacc., is frequently associated with the Coniothyrium on raspberry canes killed by it the preceding summer. (Plate XXIV, fig. 6.)[47] The same thing has been observed previously by others and most writers have followed Fuckel and Saccardo[48] in the assumption that these fungi are two forms of one species. However, it appears that the only evidence of such relationship is the intimate association of the two forms.

In the spring of 1903 the writer set out to learn the truth about this matter. Dilution cultures of Leptosphæria spores were made in potato agar in petri dishes. Individual spores were located and kept under observation during germination. As soon as they had made sufficient growth they were transferred to sterilized plugs of sugar beet. Five cultures of undoubted purity, from five separate Leptosphæria spores, were thus obtained. In all of these cultures there appeared an abundance of Coniothyrium spores indistinguishable from those obtained directly from raspberry canes. This is positive proof that the raspberry Coniothyrium is genetically related to *Leptosphæria coniothyrium* as has been suspected. It may be added that no indication of an ascogenous form appeared in any of the cultures.

Leptosphæria coniothyrium forms black patches on dead canes of both black and red raspberries. At Geneva, the perithecia ripen in April. Normally, the spores have three very distinct septa, but uniseptate spores are not uncommon. (Plate XXIV, fig. 4.)

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[46] Stewart and Eustace (151). Host Herbarium Specimen No. 60.
[47] Host Herbarium Specimen No. 61.
[48] Fuckel (44, p. 115); Saccardo (115, 2:29).

In order to learn how long *Leptosphæria coniothyrium* may live on dead raspberry canes lying on the ground the following experiment was made: In April, 1903, ten pieces of red raspberry canes, all well covered with Coniothyrium and some of them showing also Leptosphæria, were placed on the surface of the ground and protected by a slatted cage. Four years later (April, 1907) the canes were carefully examined. They were still in a fair state of preservation. Not a single spore of Coniothyrium could be found on any of them; but one cane showed some Leptosphæria perithecia. One perithecium, in particular, seemed to be in perfectly fresh condition. It was well filled with asci containing plump, fresh spores, some of which were uniseptate like those shown in Plate XXIV, fig. 4. That the fungus was *Leptosphæria coniothyrium* there can be no doubt. Dilution cultures of this perithecium were made in acidulated potato agar. Some of the Leptosphæria spores were seen to germinate, but they became overgrown with other fungi and were lost. Although numerous transfers were made onto plugs of sugar beet none of them produced Coniothyrium. Thus it appears that the fungus was still alive at the end of four years, but the proof is not as conclusive as it would have been had the Coniothyrium been obtained.

MOLD ON CANES, *Botrytis patula* Sacc. & Berl. This fungus has been reported on raspberry canes in New Jersey[49] and Connecticut.[50] On July 22, 1901, the writer found it very abundant at Milton, N. Y., on red raspberry canes from which the fruit had been removed recently. The lower portion of the canes, from the ground upward for a distance of six to twelve inches, was covered with a conspicuous growth of pale yellow or yellowish-white cottony fungus which was most abundant along the longitudinal cracks in the bark. The characteristic features of the fungus are its large, ellipsoidal spores measuring 20 x 30 μ and faintly tinged with yellow; and its coarse, rigid hyphæ branching at right angles. (Plate XXIV, fig. 2.) Probably, this fungus is only a saprophyte

[49] Kellerman (68).
[50] Clinton (22, p. 274).

and had nothing to do with the death of the canes, which seemed to be due to a severe attack of *Leptosphæria coniothyrium*. In June, 1909, the writer collected *Botrytis patula* on dead currant canes in the same locality.

ROSE.

Rosa spp.

LEAF SPOT, *Mycosphærella rosigena* (E. & E.) Lindau.[51] In a Geneva greenhouse inspected during January, 1910, there were found several potted hybrid tea roses of one season's growth on which a fungus leaf spot was rather prevalent. The disease first manifests itself as reddish or purplish blotches on the leaves which later develop into sharply defined spots with a purplish border and a dead, brown center. These spots are roundish with somewhat irregular margins and from 2 to 11 mm. in diameter. The dead, brown tissue in the center of the spot is generally freely dotted with black perithecia. Although the perithecia were very plentiful much difficulty was experienced in obtaining ripened specimens. Only a few ripe perithecia were obtained from leaves collected early in January and no better success was had with leaves taken from the same plants the last week in February. However, enough ripe perithecia were obtained for the identification of the fungus which proved to be *Mycosphærella rosigena* (E. & E.) Lindau.[52] The one-year-old plants were considerably more affected than two-year-old plants of the same variety in an adjacent bed. The greenhouse attendant informs us that the disease appears every winter but is never sufficiently abundant to cause serious damage. This may be due to the failure of the spores to ripen in large numbers which in turn may be due to the low temperature of the greenhouse, about 60° F.

Mycosphærella rosigena was first discovered on leaves of cultivated roses from Louisiana[53] and has since been reported by Hal-

[51] By S. M. McMurran.
[52] Host Herbarium Specimen No. 62.
[53] Ellis and Everhart (32).

sted[54] as being of rather common occurrence in New Jersey; but it has not been previously reported from this State.

Powdery mildew, *Sphærotheca pannosa* (Wallr.) Lév. In New York, as elsewhere, roses grown under glass are often severely injured by a powdery mildew which appears only in the conidial stage. The writer has never seen perithecia on mildewed roses under glass. In the absence of perithecia it is usually impossible to identify species of powdery mildew with certainty. Roses in the open air, also, are much subject to mildew and, here, perithecia are sometimes found. However, Salmon holds that roses in America are attacked by two species of powdery mildew, viz., *Sphærotheca pannosa* and *S. humuli,* and that the fungus which has passed here under the name *S. pannosa* is for the most part *S. humuli.* He says,[55] "I have seen only two specimens of true *S. pannosa* from America."

The Station receives numerous complaints of powdery mildew on Crimson Rambler roses. This variety is particularly susceptible. Although the leaves may be severely attacked by mildew it is usually the buds which suffer most. Frequently, the unopened buds are white with mildew before the leaves are affected to any great extent. Affected buds may open and produce flowers of fair quality, but they are likely to be undersized. On Crimson Rambler stems near the tips of the shoots there occur, also, dense patches of white, dirty white or brownish mycelium. In winter, after the leaves have fallen, these patches of mycelium are sometimes conspicuous. In January, 1910, a correspondent at Leeds, N. Y., sent us some mildewed Crimson Rambler stems on which perithecia were abundant. Undoubtedly, the fungus was *Sphærotheca pannosa.* An examination of Crimson Rambler roses on the Station grounds, made about this time, revealed the presence of *Sphærotheca pannosa* perithecia in abundance. Some of the perithecia contained ascospores which were morphologically mature. A rose bush growing on the side of a nearby house, also, showed many perithecia on the stems. Some of these specimens were sent to Dr.

[54] Halsted (53, p. 381).
[55] Salmon (116, p. 69).

Salmon, who identified the fungus as *Sphærotheca pannosa.*[56] In February, 1910, a few perithecia were found in a small patch of mycelium around the base of a prickle on a Crimson Rambler stem from a yard in Geneva. In all of the cases above mentioned the perithecia unquestionably belonged to *S. pannosa.*

Dr. Salmon has made the following statement:[57] "Although *S. pannosa* in its Oidium stage (*O. leucoconium* Desmaz.) often covers the upper surface of rose leaves, I have not been able to find, in the considerable amount of material examined, any perithecia formed here." The writer has seen perithecia, which he believes to be those of *S. pannosa,* on both surfaces of rose leaves. The circumstances were as follows: On the Station grounds there are some bushes of *Rosa humilis* which are shaded during a portion of each day. In the summer of 1910 these roses suffered a mild attack of powdery mildew. As early as August 19th perithecia were numerous on both surfaces of the leaves and many of them contained ascospores.[58] The mildew was confined to the leaves except in one case. In November a single young cane showed small patches of mycelium with imbedded perithecia around the base of each of several prickles. The fungus on this cane was certainly *S. pannosa.* Apparently, the perithecia on the leaves were in no wise different, morphologically, from those on the cane. However, the perithecia on the leaves were free and merely gregarious while those on the cane were closely clustered and imbedded in the mycelium. This difference may be due to difference in habitat. Of course it is possible that the bushes were infested by two species of mildew, but this appears improbable. Figure 90 in Duggar's Fungous Diseases of Plants represents a rose leaf bearing perithecia of *Sphærotheca pannosa.* The specimen from which this illustration was made was taken from the above-mentioned bushes in the autumn of 1907 when perithecia on the leaves were quite as abundant as in 1910.

[56] Host Herbarium Specimen No. 63.
[57] Salmon (116, p. 67).
[58] Host Herbarium Specimen No. 64.

FASCIATION. Fasciated rose canes are not uncommon. The Station museum contains a specimen[59] found in a Geneva nursery by Charles McGuigan, Orchard Foreman at the Station. The fasciated portion is one-half meter long. From the lower end, where it is nearly round and about 10 mm. in diameter, it gradually flattens and widens toward the upper end where the width is 30 mm. Twelve normal round branches spring from near the upper end. The prickles on the fasciated stem are normal. The variety is Dorothy Perkins.

In 1902, August Rahner, a florist of Villisca, Iowa, sent the writer a description and photograph of an exceptionally interesting example of a fasciated rose cane growing on his grounds. In this case the rose was one of the climbing varieties. A certain plant had seven normal canes and one fasciated cane. The fasciated cane was somewhat more than two meters long and had four separate fasciated sections alternating with sections of cane of the normal kind. The fasciated section nearest the root occupied about one-half the entire length of the cane, being 1.16 meters long by 75 millimeters wide. (See Plate XXV.)

RYE.

Secale cereale.

POWDERY MILDEW, *Erysiphe graminis* DC. On June 13, 1910, a field of rye near Geneva was found to be severely attacked by *Erysiphe graminis*. Almost all of the leaves up to a hight of about two feet were thickly covered with the fungus. Many of the leaves were already dead and brown. Perithecia were numerous even on living green or yellowish leaves. They occurred on both surfaces of the leaf but were more numerous on the upper surface. The perithecia contained asci but no ascospores were seen.[60] By July 7th the leaves were all dead and dry, yet there were no ascospores in the perithecia.

A milder attack of *E. graminis* on rye was observed at Oneida on June 22, 1910.

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[59] Museum Specimen No. 140.
[60] Host Herbarium Specimen No. 65.

SNOWBERRY.

Symphoricarpos racemosus.

ANTHRACNOSE, *Glœosporium* (?) sp. During the past three years some snowberry bushes growing on the Station grounds have been affected with a disease which disfigures the leaves and berries and sometimes attacks also the new canes. It first came to our attention in the latter part of June, 1908, and continued in evidence throughout the remainder of that season. In 1909 and 1910 it was again observed on the same plants; also, on plants in Smith Park, Geneva, where it was quite destructive. Having been unable to find any published account of such a disease of snowberry, the writer has thought it worth while to give the following description of it even though little is known concerning the systematic position of the causal fungus.

Specimens of the diseased leaves collected July 1, 1908, bore roundish dead spots two to four millimeters in diameter.[61] Occasionally, larger diseased areas were formed by the coalescence of two or more spots. On the upper surface the spots had a gray central area surrounded by a wide brown or black border. Leaves taken from the same plants on September 2, 1908, and September 29, 1909, presented a somewhat different appearance. The spots were now very numerous, many of them being merely gray specks. Most of the larger spots had run together in such manner as to form large irregular areas of brown and gray color. The dark-colored borders of the spots were no longer conspicuous. During August and September the berries show conspicuous brown or black spots which are usually somewhat sunken.[62] Affected berries frequently become misshapen and sometimes shrivel into shapeless brown masses. In July, the young canes may show spots similar to those on the leaves.

The disease is plainly of fungous origin. Microscopic preparations made from scrapings from the upper surface of the leaf spots contain, almost constantly, hyaline, elliptical, non-septate spores

[61] Host Herbarium Specimen No. 66.
[62] Museum Specimen No. 141.

measuring 4 x 6–8 μ. Such spores are more plentiful on leaves collected July 1st than on leaves collected in September. Only the one kind of spores has been found. On berries collected during dry weather no spores could be found until after the berries had been in a moist chamber for 48 hours. Similar difficulty may be experienced in searching for spores on the cane spots. Probably, the fungus is a species of Glœosporium.

According to our observation the disease on the leaves does not seriously affect the growth of the plants. Probably its worst feature is the disfiguration of the berries. The beautiful white berries of the snowberry are its chief attraction.

SWEET PEA.

Lathyrus odoratus

POWDERY MILDEW. Two cases of powdery mildew on sweet peas have come to our attention. In the latter part of August, 1910, a correspondent at Johnsonburg, N. Y., sent specimens accompanied by the statement that he had had the nicest sweet peas in the village until a few days previously when they became diseased and produced but few blooms.

The other case occurred at Geneva in 1910. From the middle of August until the close of the season the plants were completely covered with mildew. It was on leaves (both sides), stems and petioles.[63] A careful search for perithecia was made as late as September 29th, but none were found. Hence the identity of the fungus could not be determined.

No previous record of powdery mildew on sweet peas is known to the writer.

TIMOTHY.

Phleum pratense.

PROLIFEROUS FLOWERS. In the warm wet autumn of 1898 the proliferation of timothy flowers was common in New York, particularly in the vicinity of Geneva. In a field of second crop tim-

[63] Host Herbarium Specimen No. 67.

othy on poorly drained clay soil the writer collected a large number of the abnormal heads in a few minutes' time.[64] This was on October 29th. It was observed that the abnormal heads were almost always on shorter stalks than normal heads in the same stool. The leafiness of the affected heads is due to the fact that in each flower the flowering glume or lemma is transformed into a small leaf. This has been described and figured by Beal[65] and also by Toumey.[66]

TOMATO.

Lycopersicum esculentum.

Tomatoes grown in one of the Station greenhouses during the winter of 1909–10 behaved strangely. The plants grew in very rich soil and were given an abundance of water. It is our opinion that the abnormalities described below were, in some way, the consequence of too rapid growth, but the physiological processes by which they were brought about are not clear.

CRACKING OF STEMS. About the middle of December several of the plants suddenly developed a deep transverse crack in the stem six to eight inches below the tip of the shoot. At the point of injury the stems were 12 to 15 mm. in diameter. In some cases the crack extended more than half way through the stem. (Plate XXVI.) The edges of the crack were nearly as smooth as if the stem had been cut with a knife. On all but three of the plants the wound soon healed so that the leader was not lost.

LEAVES AND SHOOTS FROM FLOWER CLUSTERS. During January it was a common thing to find the terminal portion of a flower cluster prolonged into a leaf.[67] More often still a leafy shoot developed from this point. In some cases such shoots attained a length of two feet and produced flower clusters of their own. Whether the outgrowth was a shoot or merely a leaf the diameter of its axis was much greater than the diameter of the axis of the

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[64] Host. Herbarium. Specimen. No. 68.
[65] Beal (13, p. 37).
[66] Toumey (157).
[67] Host Herbarium Specimen No. 69.

flower cluster from which it sprung. The change in diameter was so great and so sudden as to be very striking.

This is what Masters[68] calls "terminal prolification of the inflorescence." It was most common on plants from seed of the variety Selected Coreless crossed with Earliana, but it occurred, also, on Lorillard and some other varieties. In Bailey's Survival of the Unlike (p. 117) there is a copy of Dunal's figure of *Lycopersicum pyriforme* which shows a flower cluster prolonged into a leafy shoot. This illustrates well the phenomenon described above except that it does not show the change in the diameter of the axis.

Shoots from leaves. On very many of the leaves upright, leafy shoots sprung from the midrib.[69] Often three or four, and sometimes several, shoots appeared on the same leaf. What hight these shoots might have attained is not known since the gardener in charge cut off the most vigorous ones. However, many of them reached a height of 10 to 15 cm. They originated in adventitious buds, invariably on the upper surface of the midrib opposite the point of attachment of lateral leaflets. Sometimes two or three shoots started from the same point.

Probably, this is of the same nature as the case described and illustrated by Ducharte, sixty years ago, in which tomato leaves gave rise to small shoots bearing both leaves and flowers.[70]

VARIEGATED VINCA.

Vinca major.

Wilt, *Phama* sp. What appears to be an undescribed disease of the variegated vinca was observed in a Batavia greenhouse during December, 1909. The affected plants were in 4-inch pots set along the edge of a carnation bench. Many of the plants had one or more shoots either dead or dying. Some of the dead shoots were already dry while others had only recently wilted. Usually, but

68 Masters (80, p. 103).
69 Host Herbarium Specimen No. 70.
70 Duchartre (26).

not invariably, the shoots were dead from their tips to the surface of the soil. The color of the dead shoots was dark brown except at the surface of the soil where it was usually gray for a distance of 12 to 25 mm. This gray section was thickly studded with small dark-colored bodies which, under a hand lens, were readily recognized as the pycnidia of some fungus. Even on recently wilted shoots the pycnidia were plentiful near the surface of the soil; but they occurred on no other portion of the dead shoots. Plainly, the seat of the trouble was in this gray section of stem at the surface of the soil and the fungus found there was the cause. The fungus proved to be a species of Phoma.[71]

A month later specimens of the same disease were found in a greenhouse at Geneva.

WHEAT.

Triticum vulgare.

POWDERY MILDEW, *Erysiphe graminis* DC. Although wheat in New York is quite frequently attacked by powdery mildew it is probably rare that any serious damage is done. One of the most severe attacks coming to the writer's notice occurred at Geneva in the spring of 1899. In some fields of winter wheat the sheaths and leaf blades were covered with mildew during May and June. Perithecia containing asci (but no ascospores) were plentiful as early as May 23d.[72] Nevertheless, there was a good yield of wheat.

Another severe attack occurred in the spring of 1910. During the latter half of April the trouble became quite general and so conspicuous as to attract considerable attention. On the Station grounds a little mildew was found on winter wheat April 10th. By April 19th so many leaves were attacked that the field appeared quite yellow and it looked as if the crop might be much injured. Although the mildew was followed by a severe attack of rust a yield of about 40 bushels per acre was obtained.

[71] Host Herbarium Specimen No. 71.
[72] Host Herbarium Specimen No. 72.

On May 5, 1910, a report was received stating that some wheat fields at Baldwinsville had been nearly ruined by mildew. Probably the damage was overestimated.

STINKING SMUT, *Tilletia fœtens* (B. & C.) Trel. A Brockport farmer estimated that ten per ct. of his wheat crop was ruined by stinking smut. The wheat was of the variety Dawson's Golden Chaff. The specimens of smutted wheat heads which he sent were attacked by *Tilletia fœtens.*

To the unaided eye, the two species of Tilletia occurring on wheat are indistinguishable, but with the aid of a microscope they are readily separated by the markings on the spores. The spores of *T. fœtens* are perfectly smooth while those of *T. tritici* bear conspicuous winged reticulations.

STINKING SMUT, *Tilletia tritici* (Bjerk.) Wint. In August, 1910, wheat heads affected with stinking smut were received from Perry, N. Y., accompanied by the following statement: "Certain spots have been affected this way for the past ten years and in each rotation the same spots show up and appear to grow larger. I have treated my seed with formaldehyde and with no apparent benefit although the same treatment for smut in my oats has given splendid results."

Upon microscopic examination the smut proved to be *Tilletia tritici.*[73]

LEAF SPOT, *Septoria graminum* Desm. ? A species of Septoria, probably *S. graminum,* was quite plentiful on leaves of winter wheat on the Station grounds during the second week of April, 1910. Usually, it was found on dead brown leaf-tips which were thickly covered with pycnidia well filled with spores. However, it also occurred on semi-circular, dead brown spots, 5 to 7 mm. in diameter, situated on the margins of green leaves in such manner as to leave little doubt as to its parasitism.[74] In Europe, *S. graminum* is considered a wheat parasite of some importance,[75] but in America it has received only passing notice.

[73] Host Herbarium Specimen No. 73.
[74] Host Herbarium Specimen No. 74.
[75] Mangin (77); Krüger (70).

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REPORT

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TABLE OF CONTENTS.

REPORT OF DEPARTMENT OF CHEMISTRY.

CHEMICAL INVESTIGATION OF BEST CONDITIONS FOR MAKING THE LIME-SULPHUR WASH.*

L. L. VAN SLYKE, A. W. BOSWORTH AND C. C. HEDGES.

SUMMARY.

1. **Object.**—The work described in this bulletin is a continuation of work published in Bulletin No. 319 and has had for its general object a study of conditions that enable one to utilize the lime and sulphur most completely and with largest formation of the compound containing most sulphur, calcium pentasulphide (CaS_5).

2. **Effect of varying proportions of lime and sulphur.**— In several experiments, we used 35.7 pounds of lime and 50 gallons of water, while the amount of sulphur varied from 35.7 to 107 pounds, or in the ratio of one to three times the amount of lime used. The ratio of lime and sulphur to water varied from 1:2.9 to 1:5.8.

(a) Sediment.—The amount of sediment varied from 2 to 35 pounds or from 1.8 to 35 per ct. of the lime and sulphur used. The largest amount occurs when the excess of sulphur is greatest in proportion to lime (3:1). The sediment is least when the ratio of lime to sulphur is about 1:2 and this increases when the ratio of lime to sulphur increases.

(b) Sulphur in solution.—The proportion of sulphur used that goes into solution is least when the proportion of sulphur is greatest (3 of sulphur to 1 of lime) and increases as the proportion of sulphur to lime decreases, until practically all of the sulphur is changed into soluble compounds when the amount of sulphur used is not more than 2.25 times the amount of lime used.

*A reprint of Bulletin No. 329.

(c) Sulphides.—The largest amount of sulphur appears as sulphides of calcium (CaS_4 and CaS_5) when the ratio of sulphur to lime is between 2.25:1 and 2:1. When more lime is used than 1:2 of sulphur, the amount of sulphide sulphur decreases.

(d) Thiosulphate.—Largest amounts of thiosulphate sulphur are formed when lime is used in largest amounts in proportion to sulphur.

(e) Lime.—The proportion of lime used that goes into solution is greatest (96 to 100 per ct.) when the proportion of sulphur is 2 or more times that of lime. When sulphur and lime are used in equal amounts, only 50 per ct. of the lime goes into solution.

(f) Ratio of lime and sulphur in solution.—However large an amount of sulphur is used in relation to lime, the amount appearing in solution is limited and is usually about 2 to 2.2 parts for 1 part of lime. When sulphur is used in excess of these amounts, it goes unchanged into sediment.

(g) Formation of different sulphides.—When sulphur is used in largest proportions to lime, larger amounts of pentasulphide (CaS_5) are formed. When less sulphur is used than 2.25 parts for 1 part of lime, less pentasulphide and more tetrasulphide (CaS_4) are formed.

3. Effect of varying proportions of water.—In another set of experiments, we used 50 pounds of lime and 100 pounds of sulphur but varied the water from 70 down to 30 gallons, so that the ratio of lime and sulphur to water varied from 1:3.9 to 1:1.7.

(a) Sediment.—The amount of sediment is least when we use most water in proportion to lime and sulphur.

(b) Sulphur in solution.—The percentage of sulphur used, going into solution, varies from 85 to 99.7, the largest percentages occurring when the largest proportion of water is used and decreasing as the proportion of water decreases.

(c) Sulphide sulphur.—The proportion of sulphur appearing in solution as sulphides does not vary widely whether we use more or less water.

(d) Thiosulphate.—The proportion of thiosulphate found decreases with the proportion of water used, owing to conversion of thiosulphate into insoluble sulphite.

(e) Lime.—The proportion of lime going into solution is greatest (99.7 per ct.) when the proportion of water is greatest, and least (68.6 per ct.) when least water is used.

(f) Formation of different sulphides.—Under the conditions of the experiments, larger amounts of pentasulphide (CaS_5) are formed when the ratio of water to lime and sulphur is less than 3:1.

4. Additional experiments.—A set of experiments was made in which we used 2.25 parts of sulphur for 1 part of lime and varying proportions of water. When we use 35.7 pounds of lime, 80.3 pounds of sulphur and 50 gallons of water, we obtain, all things considered, the most satisfactory results. The proportion of sediment is small; the percentages of sulphur and lime going into solution are large; the percentage of sulphur used that appears as sulphides is large; and the sulphide sulphur is practically all in the concentrated form of pentasulphide.

5. Effect of concentration of lime-sulphur solutions by boiling. —In concentrating a solution from 50 down to 20 gallons, the chief chemical change occurring is the conversion of thiosulphate into sulphite and free sulphur, in one case 81 per ct. of the thiosulphate being thus changed. Concentrated commercial lime-sulphur solutions contain small amounts of thiosulphate, probably as a result of concentration by boiling.

6. Some of the chemical changes in making lime-sulphur solutions.—Ordinarily, about 17 to 20 per ct. of the sulphur used goes to form thiosulphate, and this is changed, to a greater or less extent, into sulphite, the extent of the latter change depending upon length of boiling and concentration of solution. One part of calcium combines with about 2.25 pounds of sulphur to form soluble compounds. When sulphur is used in excess of these proportions, the surplus goes unchanged into the sediment as free sulphur. When sulphur is used in smaller propor-

tions than 2 to 1 of lime, not enough sulphur is present to combine with the lime and the unused lime appears in the sediment.

7. Conditions favorable to formation of sediment are (a) conditions favoring formation of sulphite; (b) impurities in lime or sulphur; (c) lime used in excess; (d) sulphur used in excess.

8. Efficiency of lime-sulphur solutions in relation to chemical composition.—The effectiveness as a spraying solution stands in a close and direct relation to the amount of sulphide compounds contained in solution, whether these compounds act directly or simply decompose into other compounds that produce the desired results.

9. Keeping-power of solution—A lime-sulphur solution which had been kept in a stoppered bottle was examined when one month old and found to have undergone no appreciable change.

10. Analysis of crystals.— In a barrel of concentrated lime-sulphur solution, large crystals were formed, which, on analysis, were found to consist of a mixture of about equal parts of tetrasulphide and pentasulphide.

11. Relation of density of solution to percentage of sulphur as a basis for dilution.—An examination of many lime-sulphur solutions, varying widely in density, shows a generally lower percentage of sulphur in relation to density, measured in degress, Beaumé, when the density is lower. The data are used in preparing a table of values varying with density, from which dilutions can be made for different uses of lime-sulphur solution, so that one gallon of diluted solution shall contain a certain number of ounces of sulphur. These dilutions applied to solutions of known composition indicate a greater degree of uniformity and accuracy than shown by other methods of dilution in practice.

12. Efficiency of different formulas used for lime-sulphur wash.—As a result of the investigation embodied in this bulletin, the following proportions are recommended for making lime-sulphur solutions: 36 pounds of lime (based on pure lime, CaO), 80 pounds of high-grade, finely-divided sulphur, and

50 gallons of water. When lime containing 95 per ct. or less than 95 per ct. of calcium oxide is used, more than 36 pounds must be taken, according to amount of impurities (38 pounds for 95 per ct. lime and 40 pounds for 90 per ct. lime), but no lime should be used containing less than 90 per ct. of calcium oxide or more than 5 per ct. of magnesium oxide. In boiling the solution, the liquid must not be allowed to drop more than slightly below the 50-gallon level.

13. Method for approximate determination of impurities in lime.—This test is based upon the fact that when one part of pure lime and two parts of sulphur are boiled with plenty of water for one hour, only slight amounts of sediment appear. If the lime contains impurities, these appear as sediment, the amount of sediment being an approximate measure of the amount of impurities.

INTRODUCTION.

In Bulletin No. 319 of this Station, we published the results of work done in 1909 relating to some of the conditions affecting the chemical composition of the so-called lime-sulphur wash. The work suggested several additional questions for investigation, which have been studied since and the results of our recent work are given in the following pages.

Among the points studied, the following are of chief interest and importance:

(1) Conditions under which it is possible to get the largest amount of lime and sulphur most completely into soluble combination.

(2) Conditions under which it is possible to produce a lime-sulphur solution containing the largest amount of calcium penta-sulphide (CaS_5).

(3) Effect of concentration of lime-sulphur solution by evaporation at boiling temperature.

(4) Some of the chemical changes occurring in the making of lime-sulphur solutions.

(5) Conditions favorable to the formation of sediment in lime-sulphur solutions.

(6) Efficiency of lime-sulphur solutions in relation to chemical composition.

(7) Keeping-power of lime-sulphur solutions on standing.

(8) Analysis of crystals formed in concentrated lime-sulphur solutions.

(9) Relation of density of solutions to percentage of sulphur as a basis for dilution.

(10) Efficiency of different formulas.

(11) Method for the approximate determination of impurities in commercial lime.

These subjects are discussed in a way to connect certain phases of practical application with the underlying chemical facts. Those who are interested in understanding the reasons for certain conclusions may find the entire bulletin useful. Those who care solely for the practical applications without an understanding of underlying principles will be interested chiefly in the last two or three topics.

COMPOUNDS OF CALCIUM AND SULPHUR.

Before taking up the details of our investigation, we will review briefly some fundamental facts relating to the chemistry of the lime-sulphur solution. When we heat a mixture of water, sulphur and lime (calcium oxide, CaO) or of slaked lime (calcium hydroxide, CaH_2O_2), the sulphur combines with the calcium (Ca) contained in the lime compound. As a matter of fact, when lime (calcium oxide) is used, it is converted into slaked lime (hydroxide) before chemical reaction occurs between the lime and sulphur. A definite amount of calcium can combine with varying amounts of sulphur so as to form, at least, five different compounds. Only two of these compounds are present in the freshly-prepared solution, the 4-sulphur compound or *calcium tetrasulphide* (CaS_4) and the 5-sulphur compound or *calcium pentasulphide* (CaS_5). Calcium pentasulphide contains 20 per ct. of

calcium and 80 per ct. of sulphur, which is at the rate of 4 parts of sulphur by weight for 1 part of calcium. Calcium tetrasulphide contains 24 per ct. of calcium and 76 per ct. of sulphur, which is at the rate of 3.2 parts of sulphur by weight for 1 part of calcium.[1]

Calcium tetrasulphide and calcium pentasulphide are easily soluble in water, producing an orange-red liquid, which in concentrated condition is strongly caustic, injuring the skin and burning foliage.

In the chemical changes that take place between lime and sulphur when they are heated in water, another compound is unavoidably formed, but in smaller amounts; this is *calcium thiosulphate* (CaS_2O_3), which is easily soluble in water and is therefore contained in the solution along with the sulphides of calcium. Calcium thiosulphate on exposure to air is changed into *calcium sulphite* ($CaSO_3$) and sulphur. Calcium sulphite is insoluble in water and therefore appears in the sediment or the undissolved portion of lime-sulphur preparations, usually forming the chief part of the sediment. The free sulphur formed by decomposition of thiosulphate recombines with calcium and goes into solution in the operation of making lime-sulphur solutions when enough lime is present.

On exposure to air, even at ordinary temperatures, calcium pentasulphide and calcium tetrasulphide absorb oxygen and slowly change into calcium thiosulphate, with free sulphur which separate out as a fine deposit.

EXPERIMENTAL WORK.

In carrying out the necessary experiments, the proportions of lime, sulphur and water have been varied within limits suggested by our previous work. The lime used in the laboratory experiments was pure lime (CaO); the sulphur was high-grade flowers of sulphur in finely divided condition. The general method of conducting the individual experiments has been as follows: The

[1] Bulletin No. 319, pp. 387–389.

desired amounts of lime and sulphur and water were accurately weighed. The laboratory experiments were carried out on the basis of the use of one-half gallon of water. These were supplemented later by making the solution in 50-gallon quantities.

During the operation of boiling, hot water was added from time to time in amounts sufficient to keep the liquid at its original level, as indicated conveniently by the use of a marked stick. After actual boiling had continued one hour, the mixture was allowed to cool and then water was added in just the amount necessary to bring the weight up to that of the original mixture; it was found that the addition of water to a given weight is more accurate for experimental work than adding to a given level. The whole mixture was filtered after boiling and dilution, and the sediment was weighed. The filtered solution was used for analysis, the following determinations being made: (1) Specific gravity, (2) total sulphur, (3) sulphur as sulphides (CaS_4 and CaS_5), (4) sulphur as thiosulphate (CaS_2O_3) and (5) calcium (Ca) or lime (CaO).

EFFECT OF VARYING PROPORTIONS OF LIME AND SULPHUR.

We will first consider some illustrative cases in which different proportions of sulphur were used for a fixed amount of lime, the amount of water being the same. The results are presented and discussed below under the following headings: (1) Proportions of lime, sulphur and water used; amounts of solution and sediment. (2) Amounts of sulphur and lime in solution. (3) Percentage composition of solution.

Proportions of lime, sulphur and water; amounts of solution and sediment.— In each of the experiments presented in the three tables following, we used 35.7 pounds of lime and 50 gallons of water, while the amount of sulphur varied from 35.7 to 107 pounds, or in the ratio of one to three times the amount of lime used. Stated on the basis of 50 pounds of lime, the water used would be 70 gallons and the sulphur would vary from 50 to 150 pounds.

Since we used the same amount of water (50 gallons) in each experiment and the sum of the sulphur and lime varied, the ratio of the amount of water to the lime and sulphur used varied also; for each pound of lime and sulphur used, we had from 2.9 to 5.8 pounds of water. The detailed data covering these and other points are presented in Table I following. Experiments 3 and 4 are duplicates and serve to show variations possible in experiments made under approximately uniform conditions.

TABLE I.— AMOUNTS OF MATERIALS USED AND OF SEDIMENT FORMED.

No. of experiment	Pounds of materials used	Pounds of sulphur for one pound of lime	Water used	Total weight of lime, sulphur and water used	Pounds of water used for one pound of lime and sulphur	Weight of sediment	Percentage of lime and sulphur used, in sediment	Weight of solution
	Lime: Sulphur	*Lime: Sulphur*	*Gals.*	*Lbs.*	*Lime and sulphur: Water*	*Lbs.*	*Per ct.*	*Lbs.*
3	35.7—107.0	1 : 3.00	50	560	1 : 2.9	35.5	25.0	524.5
4	35.7—107.0	1 : 3.00	"	560	1 : 2.9	33.0	23.1	527.0
5	35.7— 80.3	1 : 2.25	"	533	1 : 3.6	7.0	6.0	526.0
6	35.7— 71.4	1 : 2.00	"	524	1 : 3.9	2.0	1.8	522.2
7	35.7— 53.6	1 : 1.50	"	506.3	1 : 4.7	9.7	10.9	496.6
8	35.7— 35.7	1 : 1.00	"	488.4	1 : 5.8	17.0	23.8	481.4

The point of special interest to be studied in connection with the data embodied in this table is the weight and percentage of sediment, since this factor represents the chief source of loss in the manufacture of the lime-sulphur solution. The sediment in these experiments varies from 2 to 35 pounds for the amount of solution made. A somewhat better basis of comparison is the percentage that the sediment forms of the total lime and sulphur used; on this basis, the variation is from 1.8 to 25 per ct. The largest amount and proportion of sediment occurs when the sulphur used is largest in proportion to lime. Thus, when we use three pounds of sulphur for one pound of lime, one-fourth of the material does not go into solution, as shown in experiment No. 3. The sediment is least when the amount of sulphur is twice the amount of lime, as shown in experiment No. 6. It is noticeable that the amount of sediment decreases as the amount of sulphur decreases, until the ratio of sulphur to lime drops below 2:1;

when the ratio drops to 1.5:1 (experiment No. 7) and to 1:1 (experiment No. 8), the sediment increases. The reason why the sediment varies in relation to the proportions of sulphur and lime used is discussed in connection with Table II. It may be stated that the sediment obtained was mostly in a state of fine division.

Amounts of sulphur and lime in solution made with 50 gallons of water.—In the table following, the amounts of sulphur in different compounds and of lime in solution are given. The sulphur is given in three forms: (1) Total sulphur in solution; (2) sulphur present in combination as sulphides (calcium tetrasulphide, CaS_4, and calcium pentasulphide, CaS_5); and (3) sulphur in the form of calcium thiosulphate (CaS_2O_3). The sum of the sulphide sulphur and of the thiosulphate sulphur equals the total amount of sulphur in solution.

The value of each constituent is given in two ways: (1) The number of pounds in the solution made with 50 gallons of water, and (2) the percentage of each constituent used that goes into solution. For example, in experiment No. 3, when we used 35.7 pounds of lime and 107 pounds of sulphur, we find 72 pounds of sulphur in solution, which is equal to 67.3 per ct. of the sulphur used; in sulphide form we have 54.7 pounds, which is 51.1 per ct. of the sulphur used; of lime in solution we have 34.3 pounds, which is 96.1 per ct. of the lime used.

TABLE II.—AMOUNTS OF SULPHUR AND LIME IN SOLUTION MADE WITH FIFTY GALLONS OF WATER.

No of experiment	Ratio of lime and sulphur	Weight of total sulphur	Percentage of used sulphur in solution	Weight of sulphur as sulphides	Percentage of used sulphur in solution as sulphides	Weight of sulphur as thiosulphate	Percentage of used sulphur in solution as thiosulphate	Weight of lime	Percentage of used lime in solution	Pounds of sulphur for one pound of lime in solution
	Lime : Sulphur	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lime : Sulphur*
3.....	1 : 3.00	72.0	67.3	54.7	51.1	17.3	16.2	34.3	96.1	1 : 2.10
4.....	1 : 3.00	71.4	69.7	56.3	52.6	15.1	14.1	35.7	100.0	1 : 2.00
5...	1 : 2.25	77.1	96.0	63.2	78.7	13.9	17.3	34.8	97.5	1 : 2.22
6.....	1 : 2.00	71.2	99.7	57.6	80.7	13.6	19.0	35.6	99.7	1 : 2.00
7.....	1 : 1.50	53.6	100.0	41.1	76.6	12.5	23.4	27.0	75.7	1 : 2.00
8.....	1 : 1.00	33.8	94.6	24.1	67.5	9.7	27.1	17.8	50.0	1 : 1.90

In studying the data embodied in Table II, attention is called to the following facts of interest:

(1) Total sulphur in solution. The amount of total sulphur in the solution made with 50 gallons of water varies from 33.8 to 77.1 pounds. These figures do not give us any clear idea as to whether the results are satisfactory or not, except in connection with the amounts of sulphur used. We need to know the percentage of the sulphur used that goes into solution, in order to know whether or not the process is reasonably complete. In general, *the proportion of sulphur that goes into solution is least when the proportion of sulphur used is greatest (3 of sulphur to 1 of lime) and increases as the proportion of sulphur to lime decreases, until practically all of the sulphur is changed into soluble compounds, which occurs when the amount of sulphur used is not more than 2.25 times the amount of lime used.* When we use 3 pounds of sulphur for one pound of lime, as in experiments No. 3 and No. 4, not quite 70 per ct. of the sulphur goes into solution; on the other hand, nearly all (96 to nearly 100 per ct.) goes into solution when the amount of sulphur drops to 2.25 pounds or less for each pound of lime used, as shown in experiments 5, 6, 7 and 8.

(2) Sulphide sulphur. The proportion of sulphur used that goes to form calcium terta- and pentasulphide is least when the ratio of sulphur to lime is 3:1 (experiments No. 3 and No. 4) and greatest when the ratio is 2.25 or 2:1 (experiments No. 5 and No. 6); when sulphur and lime are used in a ratio of less than 2:1, the sulphide sulphur decreases (experiments No. 7 and No. 8).

(3) Thiosulphate sulphur. The proportion of sulphur used that forms thiosulphate increases as the proportion of sulphur to lime decreases. When most sulphur is used (3:1, experiments No. 3 and No. 4), about 15 per ct. of the sulphur forms thiosulphate; when equal parts of sulphur and lime are used (1:1, experiment No. 8), the proportion of sulphur that is converted into thiosulphate increases to 27 per ct.

(4) Lime. The proportion of lime that goes into solution is greatest (96 to 100 per ct.), when the proportion of sulphur is 2

or more times that of lime (experiments No. 3 to No. 6). When sulphur and lime are used in equal amounts, only 50 per ct. of the lime goes into solution.

(5) Ratio of lime and sulphur in solution. In the last column of Table II, we show the ratio of calcium, in the form of lime (CaO), and sulphur found in solution. The results indicate that *however large an amount of sulphur we use in relation to lime, the amount that appears in solution, under the conditions employed in this set of experiments, is limited and is approximately 2 to 2.2 parts of sulphur for 1 part of lime.* This point will be considered more fully later.

(6) Indications of preceding facts. The facts stated in the foregoing paragraphs point to the follow conclusions:

(a) Under the conditions of our experiments, the calcium of one part of lime combines with about two parts of sulphur to form soluble compounds, in large part calcium sulphides.

(b) When sulphur is used in excess of these proportions, the extra amount of sulphur is not acted upon but goes unchanged into the sediment as free sulphur (experiments No. 3 and No. 4, Table I).

(c) When sulphur is used in smaller proportions than 2 to 1 of lime, not enough sulphur is present to utilize for combination all the lime, and then the unused lime appears in the sediment (experiments No. 7 and No. 8, Table I).

(d) Generally speaking, if conditions favorable to the chemical reaction are observed, we get the largest proportions of sulphur and lime in solution, and therefore have the least sediment, when the proportion of sulphur used is 2 to 2.25 parts for 1 part of lime. The chemical reaction when most complete appears to call for these approximate proportions (pp. 427–8). Consequently, when we use an excess of sulphur or of lime, the excess remains unused and does not appear in the solution but is found as unchanged material in the sediment.

Percentage composition of solution. In the table following, the percentages are given of sulphur as sulphide and thiosulphate, and

of calcium in combination with sulphur as sulphide; we also state the estimated proportions of calcium tetrasulphide (CaS_4) and calcium pentasulphide (CaS_5), which make up the sulphide sulphur.

TABLE III.— PERCENTAGE COMPOSITION OF SOLUTION.

No of experiment	Ratio of	Total sulphur	Sulphur in form of sulphides	Sulphur in form of thiosulphate	Calcium in combination with sulphide sulphur	Ratio of calcium in sulphide to sulphide sulphur	Percentage of sulphide sulphur in form of tetrasulphide (CaS_4)	Percentage of sulphide sulphur in form of pentasulphide (CaS_5)	Sulphur as tetrasulphide (CaS_4) in solution	Sulphur as pentasulphide (CaS_5) in solution
	Lime : Sulphur	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calcium : Sulphur*	*Per ct.*	*Per ct.*	*Lbs.*	*Lbs.*
3.....	1 : 3.00	13.74	10.45	3.29	2.62	1 : 4.00	0.	100	0	54.7
4.....	1 : 3.00	14.18	11.29	2.89	3.03	1 : 3.73	29	71	16.3	40.0
5.....	1 : 2.25	14.66	12.02	2.64	3.07	1 : 3.92	8	92	5.1	58.1
6.....	1 : 2.00	13.64	11.03	2.61	3.25	1 : 3.40	73	27	42.0	15.6
7.....	1 : 1.50	11.47	8.94	2.53	2.83	1 : 3.20	100	0	41.1	0.
8.....	1 : 1.00	7.18	5.12	2.06	1.40	1 : 3.65	40	60	9.6	14.5

The mere difference in percentages of constituents due to difference in the proportions of water used for a given amount of lime and sulphur is not of special interest; but it is desirable to know something of the proportions of the constituents in relation to one another. The point of chief interest in connection with this table is the form of sulphide produced. In experiments 3, 4 and 5, when sulphur was used in largest proportions in comparison with lime, the largest amount of pentasulphide (CaS_5) was formed, varying from 71 to 100 per ct. of the total sulphide present. When less than 2.25 parts of sulphur for 1 of lime was used, the proportion of tetrasulphide (CaS_4) was usually greater but not uniformly so. Some condition or conditions other than the ratio of sulphur and lime used apparently influences the proportions of tetrasulphide and pentasulphide formed.

EFFECT OF VARYING PROPORTIONS OF WATER.

We will next take up the results that follow from varying the amount of water when the proportion of lime to sulphur is kept uniform. In carrying out the experiments, we used lime and sulphur in the proportions of 50 and 100 pounds, respectively,

and varied the amount of water from the extreme of 70 to 30 gallons. In order that our results may all be comparable, we have calculated them on the basis of 50 gallons of water, making the amounts of lime and sulphur correspond. The results will be discussed in the order already used in considering the preceding experiments.

Proportions of lime, sulphur and water; amounts of solution and sediment.— In each of the experiments presented in Tables IV, V and VI, we kept the proportion of lime and sulphur uniform, 2 parts of sulphur by weight for 1 part of lime, or 50 pounds of lime and 100 pounds of sulphur; in different experiments we used 70, 60, 55, 50, 40 and 30 gallons of water. The results are given for amounts corresponding to the use of 50 gallons of water. The ratio of lime and sulphur to water vary, of course, on account of the variable amount of water used. Experiments No. 21 and No. 22 represent duplicate experiments, carried on under conditions as nearly alike as possible.

TABLE IV.— AMOUNTS OF MATERIALS USED AND OF SEDIMENT FORMED.

No. of experiment	Pounds of material used	Gallons of water used	Pounds of water used for one pound of lime and sulphur	On basis of 50 gallons of water: Pounds of lime and sulphur used	Total weight of lime, sulphur and water	Weight of sediment	Percentage of lime and sulphur used in sediment	Weight of solution
	Lime: Sulphur		*Lime and sulphur: Water*	*Lime: Sulphur*	*Lbs.*	*Lbs.*	*Per ct.*	*Lbs.*
6	50 — 100	70	1 : 3.9	35.7— 71.4	524.0	2.0	1.8	522.2
11	" "	60	1 : 3.3	41.7— 83.4	542.0	3.5	2.8	538.5
12	" "	55	1 : 3.1	45.5— 91.0	553.4	8.2	6.0	545.2
16	" "	50	1 : 2.8	50.0—100.0	567.0	20.2	13.5	546.8
21	" "	40	1 : 2.2	62.5—125.0	604.5	31.7	17.0	572.8
22	" "	40	1 : 2.2	62.5—125.0	604.5	33.8	18.0	570.7
24	" "	30	1 : 1.7	83.3—166.6	667.0	60.8	24.3	606.2

In using lime and sulphur in the ratio of 1:2, we have amounts which are shown by the data in Table I to yield the least sediment when we use 35.7 pounds of lime with 71.4 pounds of sulphur and 50 gallons of water. In Table IV the data show the effect

of maintaining the lime-sulphur ratio at 1:2 but varying the amounts used in proportion to water in the manner shown in the fourth column. The results, as shown in the seventh and eighth columns of Table IV, indicate clearly that sediment increases rapidly when we decrease beyond a certain proportion the amount of water for a given amount of lime and sulphur, or, stated another way, when we increase beyond a certain point the amount of lime and sulphur for a given amount of water. The amount of sediment increases from 2 up to 60.8 pounds as the ratio of water to lime and sulphur decreases from 1 :3.9 to 1 :1.7. Expressed in percentages of lime and sulphur used, the sediment increases from 1.8 up to 24.3 per ct. as the result of increasing the concentration of the lime and sulphur in relation to water. In respect to loss of material, the best results shown by these experiments are given when we use 35.7 pounds of lime (pure CaO) with 71.4 pounds of sulphur and 50 gallons of water, in which case we have 3.9 pounds of water for each pound of lime and sulphur used.

Amounts of sulphur and lime in solution made with 50 gallons of water.— The explanation in regard to the data in Table II applies to Table V following.

TABLE V.— AMOUNTS OF LIME AND SULPHUR IN SOLUTION.

No of experiment	Ratio of lime and sulphur to water	Weight of total sulphur	Percentage of used sulphur in solution	Weight of sulphur as sulphides	Percentage of used sulphur in solution as sulphides	Weight of sulphur as thiosulphate	Percentage of used sulphur in solution as thiosulphate	Weight of lime	Percentage of used lime in solution	Pounds of sulphur for one pound of lime in solution
	L. and S. : Water	Lbs.	Per ct.	Lbs.	Per ct.	Lbs.	Per ct.	Lbs.	Per ct	Lime : Sulphur.
6....	1 : 3.9	71.2	99.7	57.6	80.7	13.6	19.0	35.6	99.7	1 : 2.00
11....	1 : 3.3	81.0	97.2	65.3	78.4	15.7	18.8	41.0	98.1	1 : 2.00
12....	1 : 3.1	89.8	98.8	74.8	82.3	15.0	16.5	43.7	96.0	1 : 2.00
16....	1 : 2.8	95.4	95.4	84.4	84.4	11.0	11.0	41.0	82.0	1 : 2.32
21....	1 : 2.2	113.3	99.6	102.0	81.6	11.3	9.9	47.9	76.7	1 : 2.40
22....	1 : 2.2	113.5	90.8	103.2	82.6	10.3	8.2	47.4	76.0	1 : 2.40
24....	1 : 1.7	141.6	85.0	132.4	80.0	9.2	5.0	57.3	68.8	1 : 2.40

The data in Table V suggest several interesting points, among which we call attention to the following:

(1) Total sulphur in solution. The amount of total sulphur in solution varies from 71.2 to 141.6 pounds, on the basis of use of 50 gallons of water. The percentage of total sulphur used that goes into solution varies from 85 to 99.7 per ct. It is seen that as we decrease the amount of water in proportion to lime and sulphur used, a smaller proportion or percentage of the sulphur goes into solution. To illustrate, in experiment No. 6, we used 71.4 pounds of sulphur and found in solution 71.2 pounds or 99.7 per ct. of the amount used; in experiment No. 24, we used 166.6 pounds of sulphur and found in solution 141.6 pounds, about twice as much as in experiment No. 6, but this was only 85 per ct. of the amount used (166.6 pounds), 25 pounds going unused into the sediment. These two experiments are alike in every respect except in relation to the ratio of sulphur and lime to water; in No. 6, the ratio is 1 :3.9, and in No. 24, it is 1 :1.7. The results of the intermediate experiments show a marked decrease in the proportion of sulphur utilized when the proportion of water to lime and sulphur decreases.

(2) Sulphide sulphur. When we consider the proportion of sulphur that goes into solution as sulphides (CaS_4 and CaS_5), it is noticeable that the decrease of water does not appear to affect the results greatly, as shown in the sixth column of Table V. So long as we have the proportions of lime and sulphur uniform, the proportion of water used within the limits shown in Table V does not increase or decrease greatly the percentage of sulphur going into solution as sulphides.

(3) Thiosulphate sulphur. In the seventh and eighth columns, the results show that, when the proportion of water to lime and sulphur decreases, the proportion of sulphur found in solution as thiosulphate decreases also; the decrease is quite regular and marked. The decrease of thiosulphate is due to its being changed into insoluble calcium sulphite ($CaSO_3$) and free sulphur (p. 289).

(4) Lime. The proportion of lime used that goes into solution is greatest (99.7 per ct.) when the proportion of water is greatest (experiment No. 6) and least (68.8 per ct.) when the proportion of water is least (experiment No. 24), under the conditions of the work.

(5) Ratio of lime and sulphur in solution. In the last column of Table V, we give the ratio of calcium, in the form of lime (CaO), and of sulphur found in solution. The results indicate that, when we have 3 or more parts of water for one part of lime and sulphur (lime and sulphur being 1:2), we have two parts of sulphur in solution for one part of lime (experiments 6, 11, 12); when the proportion of water is less than 3 parts to 1 part of lime and sulphur, an increased amount of sulphur goes into solution in proportion to lime, 2.3 to 2.4 parts of sulphur being found for one part of lime (experiments 16, 21, 22, 24). This point will be further considered later (pp. 301, 302).

(6) Indication of preceding facts. From the statement of results preceding, we are justified in stating the following conclusions:

(a) Under the conditions of the experiments, less lime and sulphur go into solution when the amount of water decreases or, stated another way, larger amounts of sediment are formed when the proportion of water to lime and sulphur decreases. The sediment under the conditions used in these experiments is largely calcium sulphite ($CaSO_3$).

(b) The proportion of sulphur that goes into solution as sulphide is not greatly different when the proportion of water to lime and sulphur varies considerably (1:3.9 to 1:1.7), other conditions being uniform.

(c) The percentages of calcium and sulphur that remain in solution as calcium thiosulphate (CaS_2O_3) grow less as the proportion of water to lime and sulphur decreases, while the amount of calcium sulphite ($CaSO_3$) increases in the sediment.

Percentage composition of solution.— In Table VI below, we give the percentages of sulphur as sulphides and as thiosulphate, and of calcium in solution in combination with sulphur as sul-

phide; we also give the calculated proportions and number of pounds of sulphur as calcium tetrasulphide (CaS_4) and calcium pentasulphide (CaS_5).

TABLE VI.—PERCENTAGE COMPOSITION OF SOLUTION.

No of experiment	Ratio of lime and sulphur to water	Total sulphur	Sulphur in form of sulphides	Sulphur in form of thiosulphate	Calcium in combination with sulphide sulphur	Ratio of calcium in sulphide to sulphide sulphur	Percentage of sulphide sulphur in form of tetrasulphide (CaS_4)	Percentage of sulphide sulphur in form of pentasulphide (CaS_5)	Sulphur as tetrasulphide (CaS_4) in solution	Sulphur as pentasulphide (CaS_5) in solution
	L. and S. : Water	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calcium : Sulphur*	*Per ct.*	*Per ct.*	*Lbs.*	*Lbs.*
6....	1 : 3.9	13.64	11.03	2.61	3.25	1 : 3.39	73	27	42	15.6
11....	1 : 3.3	15.06	12.14	2.92	3.61	1 : 3.36	76	24	50	15.3
12....	1 : 3.1	16.48	13.72	2.76	3.99	1 : 3.44	65	35	48.6	26.2
16....	1 : 2.8	17.45	15.43	2.02	4.09	1 : 3.77	24	76	20.3	64.1
21....	1 : 2.2	19.79	17.81	1.98	4.73	1 : 3.77	24	76	24.5	77.5
22....	1 : 2.2	19.91	18.11	1.80	4.80	1 : 3.77	24	76	24.8	78.4
24....	1 : 1.7	23.36	21.84	1.52	5.80	1 : 3.77	24	76	31.8	100.6

The main point of interest in this table is the form of sulphide produced. In experiments 6, 11 and 12, when dilution with water was greatest, the largest amount of tetrasulphide (CaS_4) was formed, varying from 65 to 76 per ct. of the total sulphide present. When water was used in proportions less than 2.8 parts for one part of lime and sulphur, a larger amount of pentasulphide (CaS_5) was formed, 76 per ct. in experiments 16, 21, 22, 24. Apparently, under the conditions of these experiments, there is a dividing line (3.1 parts of water to 1 part of lime and sulphur), above which dilution up to the limits used gives a larger proportion of tetrasulphide, and below which concentration or use of less water gives larger proportions of pentasulphide. As pointed out later this result does not hold good when we use sulphur in larger proportions than 2 of sulphur to 1 of lime.

ADDITIONAL EXPERIMENTS IN STUDYING EFFECTS OF VARYING PROPORTIONS OF WATER, LIME AND SULPHUR.

Thus far we have discussed two sets of experiments, in each of which variation of only one factor at a time was studied.

(1) In the first set (experiments 3–8, Tables I–III), the amount of lime (35.7 pounds) and of water (50 gallons) was kept the same, but the amount of sulphur used was made to vary from 35.7 to 107 pounds, the ratio of lime and sulphur varying from 1:1 to 1:3. (2) In the second set of experiments, the amounts of lime and sulphur used were kept uniform (50 pounds of lime and 100 pounds of sulphur), while the amount of water varied from 30 to 70 gallons, so that the ratio of lime and sulphur to water varied from 1:1.7 to 1:3.9; or, stated in another way, the amount of water was kept the same (50 gallons) while the amount of lime used was made to vary from 35.7 to 83.3 pounds and the sulphur, from 71.4 to 166.6 pounds, the ratio of lime to sulphur in every case being 1:2. In order to avoid confusion, the discussion of additional experiments involving other variations in proportions of constituents has been postponed but will be now taken up.

Several experiments were tried in which we used 50 pounds of lime and 150 pounds of sulphur with amounts of water varying from 70 to 40 gallons. We do not give the detailed results of these experiments, because we have already shown that when lime and sulphur are used in the ratio of 1:3, more sulphur is used than can possibly combine with the lime, and the unused sulphur simply goes to increase the amount of sediment. The sediment increases when the amount of water used decreases, so that we found in our experiments that from 25 to 38.5 per ct. of the lime and sulphur used goes into the sediment, the largest percentages occurring when we used the lowest amounts (40 and 50 gallons) of water. In other details, the results of these experiments agree with those discussed in Tables IV–VI in respect to the effect of using less water in proportion to lime and sulphur. Any mixture of lime and sulphur in which the ratio of lime and sulphur is 1:3 is not economical to use, whether with large or small amounts of water and we can dismiss this part of our experimental work without need of further discussion.

It is desirable, however, that we consider the experiments in which we used lime and sulphur in the ratio of 1:2.25 with varying amounts of water. Experiments 5, 10 and 15 are laboratory

experiments with pure lime; experiment 25 is on a commercial scale and the lime used was not pure. The essential facts can be brought out in the two tables following:

TABLE VII.— AMOUNTS OF MATERIAL USED AND SEDIMENT FORMED.

No. of experiment	Pounds of material used	Water used	Pounds of water used for one pound of lime and sulphur	On basis of 50 gallons of water: Pounds of lime and sulphur used	Weight of sediment	Percentage of lime and sulphur used in sediment	Weight of solution
	Lime: Sulphur	*Gals.*	*Lime and sulphur: Water*	*Lime: Sulphur*	*Lbs.*	*Per ct.*	*Lbs.*
5	50—112.5	70	1 : 3.6	35.7— 80.3	7.0	6	526
10	" "	60	1 : 3.1	41.7— 93.8	8.1	6	544
15	" "	50	1 : 2.6	50.0—112.5	17.9	11	562
25	36*—81	50	1 : 3.6	36.0— 81.0	4.2†	3.6	530

* This represents 40 pounds of commercial quicklime containing 90 per ct. pure lime (CaO).
† This is loss due to calcium sulphite and does not include the 4 pounds of useless material in the commercial lime. The total sediment is 8.2 pounds.

TABLE VIII.— LIME AND SULPHUR IN SOLUTION.

No. of experiment	Ratio of lime and sulphur to water	Percentage of sulphur used in solution	Percentage of sulphur used in solution as sulphide	Percentage of sulphur used in solution as thiosulphate	Percentage of lime used in solution	Ratio of calcium in sulphide to sulphide sulphur
	Lime and sulphur: Water	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calcium: Sulphur*
5	1 : 3.6	96	78.7	17.8	97.5	1 : 3.92
10	1 : 3.1	95.9	77.7	18.2	97.6	1 : 3.96
15	1 : 2.6	88.6	71.4	17.2	94.5	1 : 3.72
25	1 : 3.6	98.0	......	......	......	1 : 3.93

In studying Tables VII and VIII, we observe the following facts:

(1) Sediment. When we use, as in experiment No. 5, 35.7 pounds of lime and 80.3 pounds of sulphur (ratio of lime to sulphur, 1:2.25) with 50 gallons of water (ratio of lime and sulphur to water, 1:3.6), the total sediment amounts to 7 pounds, or 6 per ct. of the lime and sulphur used. The same proportion

of loss occurs in experiment No. 10 when we use 41.7 pounds of lime and 93.8 pounds of sulphur (ratio, 1:2.25) with 50 gallons of water (ratio of lime and sulphur to water, 1:3.1) When, however, we increase the lime to 50 pounds and the sulphur to 112.5 pounds with 50 gallons of water, the proportion of sediment is about double, as shown in experiment No. 15. In experiment No. 25, carried out with commercial lime and on a larger scale (50 gallons of water) than the other experiments, the actual weight of sediment found was 8.2 pounds, of which amount 4 pounds was due to impurities in the commercial lime used and 4.2 pounds to the result of regular chemical change, or the amount that would have been found if pure lime had been used. In this and several other experiments carried out on a commercial scale, the sediment has been found to be inappreciable when we use 36 pounds of lime (equal to 40 pounds of 90 per ct. lime) and 80 pounds of sulphur with 50 gallons of water. In our experience, the sediment is not only slight in amount but is very fine.

(2) Sulphur and lime recovered in solution. In Table VIII, we see that nearly all of the sulphur used (96 to 98 per ct.) is found in solution, as shown in experiments 5, 10 and 25. In experiment No. 15, when we used more lime and sulphur in proportion to water (1:2.6), less than 90 per ct. of the sulphur used was found in the solution. It is seen also that the lime goes into solution more completely when the water is used in larger proportion to lime and sulphur. The percentage of sulphur appearing as thiosulphate does not vary greatly in the different experiments.

(3) Pentasulphide and tetrasulphide. In experiments 5, 10 and 25, we have for 1 part of calcium in combination with sulphur nearly 4 parts of sulphur, which means that the sulphide is practically all in the form of calcium pentasulphide (CaS_5). In experiment No. 15, where the amounts of lime and sulphur used were greater in proportion to the water used, we have a mixture of about one-third tetrasulphide (CaS_4) and two-thirds pentasulphide.

EFFECT OF CONCENTRATION OF LIME-SULPHUR SOLUTIONS BY EVAPORATION AT BOILING TEMPERATURE.

Two experiments were made in which two different lime-sulphur solutions were concentrated by evaporation at boiling temperature. In one case the concentration was equal to the reduction of 50 gallons to 30 gallons and in the other, of 50 gallons to 20 gallons. The data of special interest are contained in the following table:

TABLE IX.—EFFECT OF CONCENTRATING LIME-SULPHUR SOLUTIONS BY BOILING

No. of experiment	Volume of solution		Density of solution		Percentage of sulphur in solution		Thiosulphate sulphur		Ratio of calcium to sulphur in sulphides		Percentage of thiosulphate sulphur changed to sulphite on boiling
	Before concentration	After concentration	Before concentration	After concentration	Before concentration	After concentration	Before concentration	After concentration	Before concentration	After concentration	
	Gals.	Gals.	Deg. B	Deg. B	Per ct.	Per ct.	Lbs.	Lbs.	Lime : Sulphur	Lime : Sulphur	Per ct.
1	50	30	21	32.8	13.74	21.43	13.45	12.30	1 : 3.72	1 : 3.70	8.5
2	50	20	24.5	33.8	16.14	25.91	15.40	2.90	1 : 3.71	1 : 3.66	81.0

The principal point of importance in connection with this table is the fact that more or less of the thiosulphate (CaS_2O_3) is changed into insoluble calcium sulphite ($CaSO_3$) and free sulphur when the lime-sulphur solution is concentrated by boiling. In the first experiment, 8.5 per ct. of the thiosulphate sulphur was changed into sulphite and free sulphur, appearing as sediment; this was equal to a loss of 1.15 pounds of thiosulphate sulphur present in the original 50 gallons of solution. In the second experiment, where the boiling was continued longer and the concentration was considerably greater, the change of thiosulphate into sulphite and free sulphur was much greater, amounting to about 81 per ct. of the thiosulphate in the original solution; this loss was equivalent to 12.5 pounds of thiosulphate sulphur for 50 gallons of original solution.

These facts serve to illustrate the effects of evaporation by long-continued boiling of lime-sulphur solutions for the purpose of pro-

ducing concentrated solutions with high percentage of soluble sulphur. Low percentage of thiosulphate sulphur is characteristic of commercial, concentrated lime-sulphur solutions. Fresh solutions containing less than 17 per ct. of total soluble sulphur usually contain 2.5 to 3.5 per ct. of thiosulphate sulphur. Concentrated solutions of commerce containing 25 per ct. or more of total sulphur usually contain only 0.6 to 0.9 per ct. of thiosulphate sulphur, rarely going above 1 per ct. This condition is suggestive that these concentrated solutions have been prepared by evaporation at boiling temperature.

The question has arisen among fruit-growers as to why home-made preparations are not as high in soluble sulphur as are commercial preparations. The reason of the difference is simply a matter of evaporation of water, and any properly home-made preparation can, if desired, be made as concentrated as any commercial mixture. While this treatment may be desirable in commercial preparations in order to reduce the cost of barreling and of transportation, it is extremely doubtful if it will ever be found economical, or for any sufficient reason desirable, for those who prepare home-made solutions. The only gain lies in reducing somewhat the number of barrels required for storage in those cases where the preparation is made some weeks or months before it is needed for use. Against the small gain in the matter of reducing the number of barrels needed for storage must be placed, (1) the cost of fuel required to concentrate the solution, (2) the amount of time used in the process and (3) the loss of thiosulphate sulphur with corresponding increase of sediment. While thiosulphate sulphur is not at present regarded as of equal value with the pentasulphide and tetrasulphide sulphur, at least for destruction of scale insects, it is of sufficient value to save from needless loss.

SOME OF THE CHEMICAL CHANGES OCCURRING IN THE MAKING OF LIME-SULPHUR SOLUTION.

The exact chemical changes taking place when lime and sulphur are boiled in water are not known in full. In the simplest kind

of change, there is formed a large amount of pentasulphide (CaS_5) or tetrasulphide (CaS_4) and a relatively small amount of thiosulphate (CaS_2O_3). If only pentasulphide with thiosulphate is formed, there is required for one pound of lime 2.28 pounds of sulphur; if only tetrasulphide and thiosulphate are formed, then the reaction calls for 1.90 pounds of sulphur for one pound of lime; if both pentasulphide and tetrasulphide along with thiosulphate are formed, the amount of sulphur required for one part of lime varies between 1.90 and 2.28 pounds. Some additional or secondary changes may take place which require more sulphur, but these are details about which we are lacking in full knowledge for the most part; though the chief and best known of these secondary changes is the formation of calcium sulphite ($CaSO_3$) and free sulphur by decomposition of calcium thiosulphate (CaS_2O_3). We will call attention to three points in connection with the ratio of sulphur and lime called for, as shown by the results of our experimental work: (1) The proportions of sulphides and thiosulphate formed; (2) the change of thiosulphate into sulphite; and (3) the proportions of lime and sulphur found in solution.

Proportions of sulphides and thiosulphate formed.—In the simplest kind of chemical change, when we have only sulphide and thiosulphate formed, about 17 to 20 per ct., or one-sixth to one-fifth, of the sulphur used goes to form thiosulphate sulphur, provided water, lime and sulphur are used in proportions such that they go into solution most completely (1 of lime: 2—2.25 sulphur. See Table II, exp's 5 and 6). Ordinarily we have in the freshly made lime-sulphur solution 4 to 4.5 parts of sulphide sulphur for 1 part of thiosulphate sulphur. When lime is used in greater proportions than 1 to 2 of sulphur, large amounts of thiosulphate appear (Table II, exp's 7-8). When a lime-sulphur solution is made with an amount of water such that the ratio of water to lime and sulphur is much below 3:1, the thiosulphate is changed to sulphite and therefore appears in much smaller per-

centage in solution (Table V, exp's 16-24); under such conditions, there may be left in solution so small an amount of thiosulphate as to form only about one-tenth of the sulphide sulphur.

Change of thiosulphate into sulphite. Small amounts of thiosulphate in solution in proportion to sulphides indicate that the thiosulphate was originally formed in the usual amounts (17-20 per ct. of solution) but has been subsequently changed into the insoluble compound, calcium sulphite, together with some free sulphur. This conversion of thiosulphate into sulphite and sulphur is favored by use of too small an amount of water in proportion to the lime and sulphur used (Table V, exp's 16-24) or by boiling too long (Table IX) or by combination of both conditions.

Proportions of lime and sulphur in solution. Taking the amounts of total sulphur and lime, equivalent to calcium, in solution in our different experiments, we find that, for one pound of lime, the sulphur varies from 1.9 to 2.40. These figures agree with the amounts called for by the reaction commonly given, as already referred to. The effect of using an amount of sulphur in excess of the proportion of 2.25 to 1 is shown by the following results:

TABLE XI.—PROPORTIONS OF LIME TO SULPHUR IN SOLUTION.

No. of experiment	Pounds used		Pounds of sulphur used for one of lime		Pounds of water used for one of lime and sulphur		Pounds of sulphur found in solution for one of lime	
	Lime:	*Sulphur*	*Lime:*	*Sulphur*	*Lime and sulphur:*	*Water*	*Lime:*	*Sulphur*
3	35.7	107	1 :	3.00	1 :	2.9	1 :	2.10
4	35.7	107	1 :	3.00	1 :	2.9	1 :	2.00
13	50	150	1 :	3.00	1 :	2.1	1 :	2.23
1	25	70.5	1 :	2.80	1 :	4.4	1 :	1.94
9	42	111	1 :	2.70	1 :	2.7	1 :	2.12
2	31	75	1 :	2.40	1 :	3.9	1 :	2.26
5	35.7	80.3	1 :	2.25	1 :	3.6	1 :	2.22
10	42	94	1 :	2.25	1 :	3.1	1 :	2.21
15	50	112.5	1 :	2.25	1 :	2.6	1 :	2.10
6	36	72	1 :	2.00	1 :	3.9	1 :	2.00
11	42	84	1 :	2.00	1 :	3.3	1 :	1.98
12	45.5	91	1 :	2.00	1 :	3.1	1 :	2.05

The fact is shown quite strikingly by the data in this table that when we use more sulphur than 2.25 parts for 1 part of lime, we do not get any more sulphur into solution in proportion to lime. When we use 3 parts of sulphur for 1 of lime, we have in solution 2 to 2.23 parts of sulphur for 1 of lime. This indicates that the chemical reaction is a fairly definite one and when we use more sulphur than can combine with the lime, the surplus sulphur remains unchanged, going into the sediment. It is obvious, also, that the amount of sulphur that combines with lime is not affected by the amount of water present. These results indicate that the most economical proportion of lime and sulphur to use is 1:2.25; with these proportions there is least possible waste in the process, since the chemical reaction appears to be complete under these conditions.

CONDITIONS FAVORABLE TO FORMATION OF SEDIMENT IN LIME-SULPHUR SOLUTIONS.

Our experiments have all helped to some extent to indicate the conditions under which sediment is formed in the manufacture of lime-sulphur solutions. It may be useful here to call special attention, by way of a summary, to the different conditions that affect the formation of sediment or insoluble matter. The causes of formation vary and also the character and composition of the sediment. The principal facts may be briefly stated, as follows:

(1) *Calcium sulphite.* In the usual method of making lime-sulphur mixtures, some calcium sulphite ($CaSO_3$) is always formed from calcium thiosulphate as an unavoidable part of the chemical changes taking place, and this compound, being insoluble, appears as sediment. It is formed in larger amounts by long-continued boiling, as when (a) a dilute solution is made more concentrated, or (b) by the ordinary amount of boiling (1 hour) when too little water is used in proportion to lime and sulphur, or (c) when the mixture becomes too concentrated in the kettle as a result of evaporation during boiling. *Plenty of water*

and avoidance of too long boiling reduce to a minimum the amount of sediment due to calcium sulphite.

(2) *Impurities in lime and sulphur.* Compounds present in lime and sulphur, which do not take any part in the chemical changes that result in the formation of the sulphides of calcium (CaS_4 and CaS_5), form part of the sediment. Of the compounds most apt to occur in quicklime or lump-lime, the following may be mentioned: Carbonate of lime, compounds of magnesium, iron, aluminum, etc. Sulphur can easily be obtained that is practically free from impurities, usually being over 99 per ct. pure; but when any insoluble impurities are present in the sulphur used, they contribute to increase the amount of sediment.

(3) *Lime used in excess.* When lime is used in amounts larger than can combine with the amount of sulphur present to form soluble compounds, the excess of lime appears as part of the sediment. Generally speaking, when we use more than one part of lime for two parts of sulphur, the amount of lime used above this proportion is unchanged and remains insoluble as part of the sediment, especially if enough water is used. This fact readily accounts for the large amounts of sediment formed when some of the old formulas were used, in which the amount of lime equalled or exceeded that of sulphur. Any lime that, through lack of complete slaking, is allowed to remain in lumps and fails to take part in the lime-sulphur reaction, goes into the sediment.

(4) *Sulphur used in excess.* Theoretical considerations, in harmony with actual experiments, indicate that when we use sulphur in proportions greater than 2.25 parts for 1 part of lime, the excess of sulphur remains unchanged, appearing in the sediment as free sulphur. For example, when we use 3 parts of sulphur for 1 of lime, 30 to 40 per ct. of the sulphur used is found in the sediment. When the ratio of sulphur to lime is 2.25 (or less) :1, we find only 1 to 5 per ct. of the sulphur in sediment and this is there not as free sulphur but as calcium sulphite, having been taken into solution and changed again to an insoluble form. Sulphur in finely powdered form easily gathers into little

lumps which are not easily penetrated by water and which may remain unchanged, passing as free sulphur into sediment. It is essential that the lime-sulphur mixture be constantly and thoroughly stirred during the process of making so as to break up as completely as possible all lumps of sulphur or of lime.

EFFICIENCY OF LIME-SULPHUR SOLUTIONS IN RELATION TO CHEMICAL COMPOSITION.

In what particular manner the lime-sulphur solution acts as an insecticide and fungicide, no one has yet clearly demonstrated. What specific compounds are directly responsible for the effects produced we are not yet certain. It is held, as the result of some experimental work, that the effect of the lime-sulphur mixture is not due to the direct action of calcium pentasulphide (CaS_5) or of calcium tetrasulphide (CaS_4), but is due rather to compounds that are formed from these, either calcium thiosulphate (CaS_2O_3), or free sulphur, or both. If the directly effective substance is calcium thiosulphate, then the amount that can be formed from the lime-sulphur solution is directly dependent upon and proportional to the amount of calcium pentasulphide or tetrasulphide in solution. If the sulphur set free from the pentasulphide, tetrasulphide and thiosulphate is the effective agent, then the amount of compounds in solution capable of furnishing the largest amount of free sulphur directly determines the value of the solution. Calcium pentasulphide is capable of furnishing more free sulphur by decomposition than the tetrasulphide and this more than the thiosulphate. If the free sulphur is the material desired, then the solution containing the largest amount of pentasulphide is the most valuable. It is now commonly believed, whether correctly or not, that the solution containing most pentasulphide is most effective, at least in connection with destruction of scale insects. Whatever may prove to be the facts in relation to the manner of action of the lime-sulphur solution, it is obvious that its efficiency stands in some close and direct relation to the

amount of sulphide compounds contained in it, or, in other words, to the chemical composition of the solution.

KEEPING-POWER OF LIME-SULPHUR SOLUTION ON STANDING.

One sample of lime-sulphur solution was examined after it had been standing for a month in a warm room in a stoppered bottle. There was a slight deposit of free sulphur. The total amount of sulphur in the fresh solution was 13.74 per ct.; at the end of a month, the sulphur in solution was 13.66 per ct., essentially the same as in the fresh solution.

ANALYSIS OF CRYSTALS FORMED IN LIME-SULPHUR SOLUTIONS.

In a barrel of concentrated lime-sulphur solution, there were deposited, after standing some months, large reddish-brown crystals. An analysis of these crystals showed them to consist of calcium sulphides with a very small amount of calcium thiosulphate. The crystals consisted chiefly of a mixture of about equal parts of calcium pentasulphide (CaS_5) and calcium tetrasulphide (CaS_4).

In an experiment, in which we used only 15 gallons of water for 50 pounds of lime and 100 of sulphur, and, after boiling, diluted to 50 gallons, needle-shaped crystals separated. The ratio of calcium to sulphur in these crystals was found to be 1:3.31, which indicates that the crystals are nearly all calcium tetrasulphide (CaS_4). The remaining solution after the removal of the crystals contains larger amounts of pentasulphide, the ratio of calcium to sulphur being 1:3.60.

RELATION OF DENSITY OF SOLUTION TO PERCENTAGE OF SULPHUR AS A BASIS FOR DILUTION.

The relation of density of lime-sulphur solutions to the percentage of total sulphur in solution is a matter of fundamental importance, because in orchard practice the extent of dilution is made to depend upon the density as measured by specific gravity,

which is preferably expressed in degrees Beaumé on account of simplicity. The method of dilution of lime-sulphur solutions is based upon the supposition that one degree, Beaumé, corresponds to the same percentage of sulphur, whether in dilute or in concentrated solutions. Previously, we have had insufficient data upon which to base reliable statements in regard to the ratio of density to sulphur content of solutions. On the basis of a few data, the statement was made in Bulletin No. 319 (p. 415) that, in general, one degree, Beaumé, corresponds approximately to 0.76 per ct. of sulphur in concentrated solutions within the limits of density indicated by 25° to 33° B. As we shall see this general statement needs some modification in the interest of accuracy. For the purpose of making as careful and complete a study as possible of the relations of density to percentage of sulphur in lime-sulphur solutions, we have brought together in Table X the results of sixty-two analyses of samples, the history of which is known to us in each case. In the fourth, fifth, ninth and tenth columns are given some additional data, to which reference will be made later.

We will now consider in detail (1) the relation of density of solution to percentage of sulphur, (2) the adoption of definite values expressing such relations, as a basis for diluting lime-sulphur solutions and (3) an application of the method of dilution to cases of known composition for the purpose of testing the accuracy of the proposed dilutions.

The percentage of sulphur corresponding to 1°B. is obtained simply by dividing the percentage of sulphur in solution by the number representing the density of that solution in Beaumé degrees.

TABLE X.—RELATION OF DENSITY OF SOLUTION TO PERCENTAGE OF SULPHUR.

Density	Percentage of sulphur in solution	Percentage of sulphur for 1° B.	Percentage of sulphur in diluted solution	Sulphur in 1 gall. of diluted solution	Density	Percentage of sulphur in solution	Percentage of sulphur for 1° B.	Percentage of sulphur in diluted solution	Sulphur in 1 gall. of diluted solution
Degrees, Beaume	Per ct.	Per ct.	Per ct.	Ozs.	Degrees, Beaume	Per ct.	Per ct.	Per ct.	Per ct.
11.9	7.18	0.60	......	.....	29.9	21.31	0.71	3.34	4.62
16.7	10.14	0.61	3.16	4.37	30.0	21.19	0.71	3.32	4.57
17.8	11.47	0.64	3.36	4.67	30.4	20.22	0.67	3.18	4.40
20.0	12.78	0.64	3.36	4.67	30.4	21.17	0.70	3.33	4.60
21.0	13.74	0.65	3.44	4.74	30.4	22.75	0.73	3.58	4.94
21.4	14.18	0.66	3.56	4.91	30.4	23.28	0.77	3.66	5.07
21.5	13.64	0.63	3.43	4.73	30.9	23.55	0.76	3.51	4.83
21.6	14.66	0.68	3.50	4.82	31.1	22.75	0.73	3.40	4.70
21.9	16.33	0.75	3.90	5.40	31.2	23.72	0.76	3.54	4.89
22.3	16.50	0.74	3.95	5.47	31.2	24.32	0.78	3.63	5.00
23.7	15.06	0.64	3.32	4.57	31.2	24.34	0.78	3.64	5.02
24.1	16.61	0.70	3.50	4.82	31.4	22.87	0.73	3.43	4.73
24.2	15.28	0.63	3.22	4.44	31.4	23.36	0.74	3.50	4.82
24.5	16.14	0.66	3.41	4.71	31.5	23.15	0.73	3.47	4.78
24.5	16.53	0.68	3.46	4.76	31.8	24.47	0.77	3.57	4.92
24.5	17.45	0.71	3.68	5.10	31.9	24.70	0.77	3.60	4.97
24.7	16.48	0.67	3.20	4.41	32.0	24.52	0.76	3.58	4.95
24.7	15.43	0.62	3.00	4.13	32.2	21.83	0.68	3.20	4.41
26.8	18.73	0.70	3.30	4.54	32.7	25.68	0.78	3.57	4.92
26.8	19.68	0.73	3.46	4.76	33.0	25.72	0.78	3.58	4.94
26.9	19.78	0.74	3.48	4.80	33.0	25.60	0.77	3.56	4.91
27.1	19.80	0.73	3.48	4.80	33.5	25.48	0.76	3.56	4.91
27.2	19.79	0.73	3.49	4.81	33.5	26.05	0.78	3.64	5.02
27.4	19.91	0.73	3.52	4.85	33.6	25.66	0.76	3.50	4.82
27.9	19.30	0.70	3.30	4.55	33.9	26.49	0.78	3.62	4.99
28.5	22.39	0.78	3.84	5.30	34.0	25.93	0.76	3.54	4.89
28.6	21.02	0.73	3.38	4.68	34.2	25.81	0.75	3.53	4.87
29.0	19.90	0.69	3.21	4.43	34.3	26.03	0.76	3.57	4.92
29.0	21.00	0.73	3.39	4.69	34.5	25.43	0.74	3.50	4.82
29.2	19.98	0.70	3.22	4.44	35.7	26.65	0.75	3.43	4.73
29.8	22.35	0.75	3.50	4.82	36.0	27.82	0.77	3.58	4.94

In examining the third and eighth columns in Table X, we notice that the percentage of sulphur corresponding to 1°B. shows a general tendency to become higher as the density increases. Below 25°B., each degree represents in most cases less than 0.70 per ct. of sulphur; in solutions testing above 25° B., each degree corresponds to about 0.75 per ct. of sulphur.

Another point to which attention should be called is the evidence of some marked irregularities; there are some cases in which solutions having the same density contain variable percentages of sulphur, as, for example, three solutions testing 24.5° B. but varying in sulphur ratio from 0.67 to 0.71, and, again, four

solutions testing 30.4° B. but varying in sulphur ratio from 0.67 to 0.77. The irregularities observed are probably about as extreme as are apt to occur and, indeed, much greater than occur in the case of properly managed home-made washes. In view of the irregularities observed in the relation of density, expressed in degrees, Beaumé, to the percentage of sulphur, the question arises as to whether we can devise any method of meeting this condition, in order that we may make use of the density in degrees Beaumé as a basis for diluting lime-sulphur solutions to the proper degree required for different purposes.

Adoption of values as basis for diluting lime-sulphur solution. In making dilutions of lime-sulphur solutions for application to trees, it is desirable that the diluted solutions contain as nearly as possible the same amount of sulphur when used for a given purpose, if it is expected to obtain uniform results. It is necessary to have the following data as a basis: (1) The amount of sulphur which a gallon of dilute solution should contain for a specific use; (2) the percentage of sulphur that is necessary to allow for each degree, Beaumé; and (3) the rate of dilution for each degree, Beaumé, which shall make the diluted solutions contain the same percentage of sulphur, or, expressed in another way, the same number of ounces of sulphur in one gallon of diluted solution.

Mr. P. J. Parrott has furnished the following information bearing on the first point: In treating San José scale, each gallon of diluted lime-sulphur solution should contain about 4.75 ounces of sulphur. This dilution is obtained approximately by diluting one gallon of lime-sulphur solution testing 33° B. with 8 gallons of water, making 9 gallons of diluted solution. In spraying for blister-mite, one gallon of solution (33° Beaumé) is diluted with 11 gallons of water; and, for fungicidal work on foliage, the dilution is 40 gallons of water for one gallon of lime-sulphur solution (33° B.). On the basis of these statements, we readily learn by making the proper calculations that one gallon of diluted

solution prepared for San José scale should contain 3.45 per ct. of sulphur; that one gallon of solution prepared for blister-mite should contain about 3.56 ounces of sulphur, which is equivalent to 2.60 per ct.; while as a fungicide, each gallon should contain 1.04 ounces of sulphur, which is equivalent to 0.775 per ct. of sulphur.

In assigning a sulphur value for each degree, Beaumé, the figures given in the second column of Table XI were adopted as making the closest practical approximation to actual facts and involving the least error. It is observed that, starting at 36° B., the sulphur value is 0.75 and that this is made gradually to decrease as the density decreases, until at 20° B. and below the value of 0.65 is given. These values have been so selected that, as will be seen later, any deviation from normal will nearly always be in the direction of diluted solutions a little above required strength, instead of more or less below.

The rate of dilution is based upon the density in degrees, Beaumé, in such a way that the diluted mixture contains the same percentage of sulphur or the same number of ounces in a gallon. The data for the calculations are given in the table below. Where the number of gallons of water to be added to one gallon of solution involves a fraction, the quarter nearest the exact figure is used for convenience; this does not impair appreciably the accuracy of the dilution, as shown by the percentage of sulphur in each diluted mixture. The details in Table XI are given for the benefit of those who desire to know upon what data the figures are based for making the different dilutions.

The percentages of sulphur in the diluted solution can be obtained by dividing the number of pounds of sulphur in one gallon of solution before dilution by the weight of the whole mixture after dilution. The number of ounces in one gallon of diluted mixture is found by dividing the number of ounces of sulphur in one gallon, before dilution, by the total number of gallons after dilution.

TABLE XI.—DATA FURNISHING A BASIS FOR DILUTING LIME-SULPHUR WASH.

Density of solution in degrees, Beaumé	Percentage of sulphur equal to 1° B.	Percentage of sulphur in solution	Weight of one gallon of solution.	Sulphur in one gallon of solution	Dilution for San José scale: For 1 gall. lime-sulphur solution	Sulphur in one gallon of diluted solution	Dilution for blister-mite: For 1 gall. lime-sulphur solution	Sulphur in one gallon of diluted solution	Dilution for summer spray: For 1 gall. lime sulphur solution	Sulphur in one gallon of diluted solution
	Per ct.	*Per ct.*	*Lbs.*	*Lbs.*	*Galls. water*	*Ozs.*	*Galls. water*	*Ozs.*	*Galls. water*	*Ozs.*
36	0.75	27 00	11.08	2.99	9	4.78	12½	3.54	45	1.04
35	0.75	26.25	10.98	2.88	8¾	4.73	12	3.54	43½	1.04
34	0.75	25.50	10.88	2.77	8¼	4.79	11½	3.58	41¾	1.04
33	0.75	24.75	10.78	2.67	8	4.75	11	3.56	40	1.04
32	0.74	23.70	10.69	2.53	7½	4.76	10½	3.52	37¾	1.04
31	0.74	22.95	10.60	2.43	7¼	4.72	10	3.53	36¼	1.04
30	0.73	21.90	10.51	2.30	6¾	4.75	9½	3.50	34¼	1.04
29	0.73	21.15	10.42	2.20	6½	4.70	9	3.52	32¾	1 04
28	0.72	20.15	10.32	2.08	6	4.75	8½	3.50	31	1.04
27	0.72	19.45	10.23	1.99	5¾	4.72	8	3.54	29½	1.04
26	0.71	18.45	10.15	1.87	5¼	4.79	7½	3.52	27¾	1.04
25	0.70	17.50	10.07	1.76	5	4.70	7	3.52	26	1.04
24	0.69	16.65	9.98	1.65	4½	4.80	6½	3.52	24½	1.04
23	0.68	15.65	9.90	1.55	4¼	4.72	6	3.54	22¾	1.04
22	0.67	14.75	9.82	1.45	3¾	4.88	5½	3.57	21¼	1.04
21	0.66	13.85	9.74	1.35	3½	4.80	5	3.60	19¾	1.05
20	0.65	13.00	9.67	1.26	3¼	4.74	4¾	3.51	18¼	1.05
19	0.65	12.35	9.59	1.18	3	4.72	4¼	3.60	17	1.04
18	0.65	11.70	9.51	1.11	2¾	4.77	4	3.55	16	1.04
17	0.65	11.05	9.44	1.04	2½	4.75	3¾	3.50	15	1.04
16	0.65	10.40	9.37	0.97	2¼	4.77	3½	3.44	14	1.04
15	0.65	9.75	9.30	0.90	2	4.70	3	3.60	12¾	1.06

It will be observed in columns 6, 8 and 10 that the dilutions have been so arranged that where fractions of a gallon are called for, quarters are used (¼, ½, of ¾), so that the figures really represent gallons and quarts, an arrangement much more convenient than having several different kinds of fractions calling for fractions of quarts. This method of using uniform fractions does not involve any appreciable error, as can be shown by examining the seventh, ninth and last columns in Table XI, in which we give the number of ounces of sulphur in each gallon of diluted solution corresponding to each density (Beaumé degrees). For example, in the seventh column, each gallon, in case of absolute uniformity of dilution, would contain 4.75 ounces; the widest variation below this is 0.05 ounce, in which case the number of ounces is 4.70 instead of 4.75; and the widest variation above is

0.13 ounce, in which case the number of ounces is 4.88 instead of 4.75. In the former case the solution is slightly weaker and, in the latter, slightly stronger, than the regular amount. Such variations are insignificant and could have no influence upon practical results. In the case of solutions for blister-mite, where the dilution is somewhat greater than for San José scale, the slight error is still smaller; and, in the case of solutions diluted for fungicide, the variation of sulphur in a gallon is less than 0.01 ounce.

Application of the method of dilution to solutions of known composition.— The preceding discussion of the data embodied in Table XI should make clear the fact that the dilutions given in the table for each degree (Beaumé) have been so adjusted as to give accurate results and make sure that each gallon of diluted solution will have the same number of ounces of sulphur, when the Beaumé degrees and the sulphur value are those given in Table XI. But we have seen in Table X that there is considerable variation in the relation of density to percentage of sulphur, and the question arises as to whether the adjustment of density to the percentage of sulphur, as given in Table XI is sufficiently accurate for practical purposes. We can test the question readily by applying to all the results in Table X the degrees of dilution given in Table XI and then ascertaining how closely the amount of sulphur which should be in the diluted solution agrees with the amount found by applying our method of dilution. We have made comparison only in case of the dilution for San José scale, because any discrepancies would be more marked than in the case of solution for blister-mite and fungi, when the dilution is greater. The results of our comparison are given in Table X in the fourth, fifth, ninth and tenth columns. The figures in these columns give both the percentage of sulphur in the diluted solution and the number of ounces of sulphur in one gallon of diluted solution. If the solutions in the sixty-two cases whose composition and density are given in Table X, were diluted on the basis of their actual content of sulphur, each gallon of diluted product would con-

tain 3.45 per ct. of sulphur, equal to 4.75 ounces per gallon. The figures for these values given in Table X represent the results obtained by applying the method of dilution given in Table XI, just as if we knew nothing about the actual composition of the solution except as estimated in that table on the basis of density in Beaumé degrees. Bearing in mind that the figures in the fourth and ninth columns should, if absolutely accurate, be uniformly 3.45 per ct., we notice that in about fifty of the sixty-two cases the variation is not more than 0.2 per ct. from 3.45. The lowest value is 3 per ct., or 0.45 per ct. low; the highest value is 3.95 per ct. which is 0.50 per ct. high. Expressed in ounces of sulphur per gallon of diluted solution, we can state the results as follows: If the solutions were accurately diluted, each gallon would contain 4.75 ounces of sulphur; but diluted on the basis of composition, as dependent upon density shown by Beaumé degrees, each gallon contains an amount of sulphur varying more or less from the correct figure (4.75). In the lowest case, one gallon of solution contains 4.13 ounces of sulphur or about one-half ounce too little of sulphur. It is doubtful if this deficiency in sulphur would appreciably affect the destructive power of the wash when applied to San José scale. In six cases, the diluted wash was one-third of an ounce below the specified amount, while in seven cases the amount was below only to an inappreciable extent. In the remaining cases, the amount was practically as required, or else more or less in excess, varying from 4.76 up to 5.47 ounces, being, in the highest case, nearly three-fourths of an ounce in excess. The values in Table XI have, in general, been so adjusted as to obtain solutions after dilution with more, rather than with less, sulphur than the required amount. It is safe to say that methods in previous use have obtained, with solutions varying widely in density, nothing like the accuracy possible with the method given in Table XI, which is based upon all the data available for making the needed calculations. The method gives most excellent results when applied to

concentrated commercial mixtures and also to home-made preparations that are properly handled during the operation of boiling.

A comparison of methods of dilution was made with two samples of lime-sulphur solution; one tested 21.6° B. and the other 33.6° B. Each one was diluted in two ways, (1st) by the method given in Table XI, and (2nd) by the method given in Bulletin No. 320, the diluted solution being made to have a density of 4.5° B. Solutions of proper strength should, after dilution, contain about 3.45 per ct. of sulphur or 4.75 ounces of sulphur per gallon. The results are indicated in the following tabulated statement:

TABLE XII.— COMPARISON OF RESULTS BY DIFFERENT METHODS OF DILUTION.

Results by old method					Results by new method		
Density of original solution	Amount of dilution	Density of diluted solution	Sulphur in diluted solution	Sulphur in diluted solution per gallon	Amount of dilution	Sulphur in diluted solution	Sulphur in diluted solution per gallon
Deg. B.	*Sol'n : Water Gals.*	*Deg. B.*	*Per ct.*	*Ozs.*	*Sol'n : Water Gals.*	*Per ct.*	*Ozs.*
21.6	1 : 4½	4.5	3.03	4.17	1 : 3¾	3.50	4.82
33.6	1 : 8½	4.5	3.44	4.69	1 : 8¼	3.50	4.82

These results show that in case of the weaker solution, dilution to 4½° B. gives too weak a spraying mixture, containing only 3.03 per ct. of sulphur, instead of 3.45, and 4.17 ounces of sulphur per gallon instead of 4.75, while dilution by the new method gives a solution of strength slightly higher than required (3.5 per ct. of sulphur or 4.82 ounces per gallon). In case of the concentrated solution, dilution by either method gives nearly the same results. It would appear, therefore, that in case of home-made mixtures, the old method of diluting to a density of 4½° B. is apt to give too weak solutions.

EFFICIENCY OF DIFFERENT FORMULAS USED IN MAKING LIME-SULPHUR WASH.

Under this head we wish to bring together various facts of interest and consider them briefly in their bearing on the advantages and disadvantages of using different proportions of lime, sulphur and water. The best combination of proportions of these constituents will meet the following conditions:

(1) *The proportions of lime and sulphur* should be such that there will be just enough of each to combine with the other without leaving any uncombined lime or sulphur to go into the sediment. This condition works for efficiency in bringing into solution all lime and sulphur, so that when fairly pure materials are used, practically no sediment is formed and never any that requires removal or other attention. The proportions of lime and sulphur which meet this condition should be, according to the results of our experiments, not less than 2 nor more than 2.25 parts of sulphur for 1 part of lime.

(2) *The proportions of lime and sulphur* should be such as to furnish the largest amount of the soluble compound containing most sulphur, calcium pentasulphide (CaS_5). This condition, as well as the one preceding, is met most completely in our experiments by using lime and sulphur in the ratio of 1:2.25.

(3) *The proportions of water to lime and sulphur* should be such as to enable the chemical changes to take place quickly and to form as concentrated a solution as possible, while utilizing with least loss the lime and sulphur. The proportion of water which we have found most effective for all purposes is about 3.5 parts for 1 part of lime and sulphur, although good results may be obtained when the water is not lower than 3 to 1 of lime and sulphur. The chemical reaction between the lime and sulphur can not take place completely unless the particles of lime and sulphur are kept in a finely divided condition and this can be accomplished satisfactorily only when the amount of water is sufficient. When the proportion of lime and sulphur to water is large, the particles

compact in masses more easily and are more difficult to break up, resulting in the formation of lumps that remain unchanged and help increase the amount of sediment. We have noticed also that when smaller amounts of water are used, the soluble thiosulphate is changed into insoluble sulphite; the amount of sediment is thereby increased, while the amount of lime and sulphur in solution is decreased.

THE GENEVA STATION FORMULA.

The combination of constituents that appears best to meet the largest number of desirable conditions is the following, stated in round numbers:

36 pounds of lime (pure lime, CaO, used as basis).

80 pounds of high-grade, finely-divided sulphur.

50 gallons of water.

In connection with this formula, it is necessary to call attention to the kind of lime and sulphur to be used and also to certain details in the operation of making the preparation.

(1) *Kind of lime.* It is desirable *to use only the best kind of fresh commercial quicklime,* commonly called stone-lime, lump-lime, etc., and this means lime containing the highest amount of calcium oxide (CaO). While slaked lime of high purity can be used, the commercial products should be avoided on account of uncertain composition and the larger amount required (at least one-third more). *Air-slaked lime should under no circumstances be used,* because it consists more or less largely of carbonate of lime, which, in experiments made by us, has proved wholly worthless, because no appreciable chemical reaction takes place when it is boiled with sulphur and water. Lime containing more than 5 per ct. of magnesium oxide should not be used, because, as shown in Bulletin No. 319, it causes unnecessary loss of sulphur, produces poisonous hydrogen sulphide, and increases the amount of sediment. It is possible to obtain commercial lime containing 95 per ct. or more of pure lime (calcium oxide, CaO) and this should be used. The use of lime containing less than 90 per ct. of pure lime should be avoided.

When lime containing impurities is used, more than 36 pounds must be taken in order to obtain 36 pounds of pure lime.

Use 38 pounds of lime containing 5 per ct. of impurities (95 per ct. pure).

Use 40 pounds of lime containing 10 per ct. of impurities (90 per ct. pure).

Use 42 pounds of lime containing 15 per ct. of impurities (85 per ct. pure).

The agricultural law of New York requires that in the case of lime sold for agricultural purposes, the minimum percentage of calcium oxide (pure lime) shall be guaranteed. No one should, therefore, purchase lime for use in making the lime-sulphur wash except under guarantee, *and only lime guaranteed to contain more than 90 per ct. of calcium oxide should be used.* For a simple method of determining approximately the purity of lime, see pages 447–449.

(2) *Kind of sulphur.* Sulphur of high-grade purity (over 98 per ct.) and as finely divided as possible, should be used. This can be easily obtained. In our experience, equally good results are given by flowers of sulphur or sulphur flour when in equally fine powder. Ground crystalline sulphur is not usually fine enough to use to advantage, since the coarser particles are not easily dissolved and therefore pass largely into the sediment.

(3) *Some details of making solution.* It is not our purpose to repeat all the well-known details of making the lime-sulphur wash, but simply to call attention to particular features that are essential to the best results in the use of the Geneva formula. Two special precautions are to be observed in addition to those usually mentioned: Keeping up the volume of solution during boiling and making the lime and sulphur as finely divided as possible.

(a) *The level of the mixture during boiling should be kept near the 50-gallon mark,* not being allowed to drop more than an inch below; this is accomplished by adding water from time to time in the required amounts. It is preferable to add water in small amounts at more frequent intervals than larger amounts less

often, since the boiling is less interfered with. When the boiling is completed, the level of the liquid should be made up to the 50-gallon mark, if not already there. The amount of water necessary to add during the boiling varies with the intensity of the fire under the kettle and also with the temperature of the surrounding air. Larger amounts must be added in warm weather than in cold. When the kettle contains 50 gallons of mixture at the close of boiling, this volume will shrink on cooling to the temperature of the air, so that when cooled there will be only 46 to 48 gallons, according to the temperature to which it is cooled. It should be remembered that the object of keeping the solution from becoming concentrated during boiling is to prevent the conversion of thiosulphate into insoluble sulphite. (b) The completeness with which the lime and sulphur combine depends, other conditions being favorable, upon getting and keeping the lime and sulphur in as finely divided condition as possible. This is accomplished in case of the lime by careful slaking; in case of sulphur, it must be brought about largely by more or less constant stirring of the mixture, especially the sediment at the bottom of the kettle. The larger proportion of water for lime and sulphur makes this easier to accomplish than in the case of formulas in which large amounts of lime and sulphur are used.

(c) Density of solution. When the solution is made to the 50-gallon mark at the close of boiling, it will be found when cooled to about 60° F. to have a density of 24° to 25° B.

We will briefly call attention to the advantages and disadvantages of the Geneva formula.

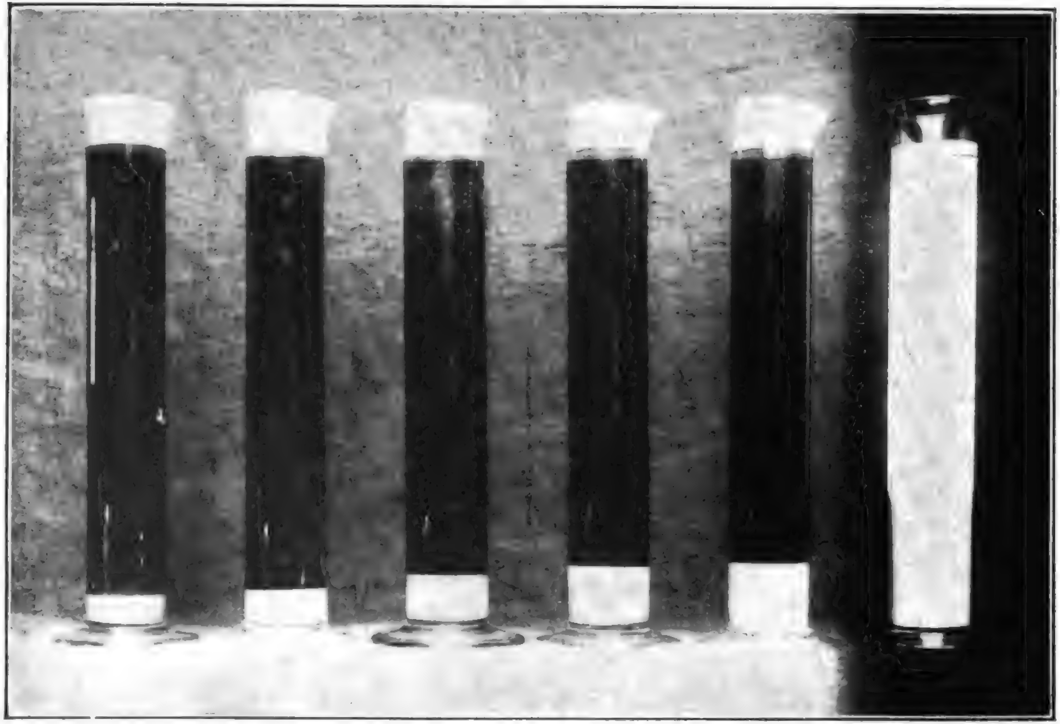
Advantages of formula.—(1) The lime and sulphur are in those proportions called for by the usual chemical reactions; the combination is practically complete for both lime and sulphur. (2) The formation of sediment, whether of unused sulphur and lime, or of sulphite formed from thiosulphate, is at a practical minimum; with fairly pure materials, there is practically no sediment. (3) The percentage of sulphur in the form of pentasulphide (CaS_5) is highest. (4) The proportion of solids to water is such

as to enable one most effectively to keep the lime and sulphur from forming lumps and therefore in the finely-powdered condition required for complete chemical action. (5) During the boiling, there is less danger of the solution becoming so concentrated as to increase unduly the formation of sulphite from thiosulphate, a condition easily occurring in case of the use of more lime and sulphur in proportion to water.

(6) Solutions made by this formula, when stored, have less tendency to change than more concentrated solutions.

(7) Solutions made at different times by this formula have, in our experience, run very uniform in composition. With other formulas, variable results are obtained at different times when working under conditions as uniform as possible.

Disadvantages of formula.— The only disadvantage that has suggested itself in our experience is the fact that the solution prepared by this formula is less concentrated; on this account, more separate boilings must be made and, if stored, a larger number of containers must be used. In comparison with the formula used by the Station during 1910 (65 pounds of lime, 125 of sulphur, and 50 gallons of water), it would require 150 gallons of the solution made by the new formula to equal 100 gallons made by the other, assuming that sediment and solution can be used or else separated without loss of solution; in other words, the time of making solution and the number of barrels for storage would be increased apparently one-half. To offset this inconvenience, the preparation of solutions by the old formula involved a loss of 32 pounds of material as sediment in comparison with 7 pounds by the new formula; the old mixture is more difficult to keep well stirred. In general, it has been the custom to throw away the sediment in whole or part and with it all the solution adhering to it, so that, of every 50 gallons prepared, considerably less than 50 gallons is actually utilized. The solution prepared by the new formula is largely or wholly pentasulphide; with the old formula, tetrasulphide chiefly was formed, with little or no pentasulphide.



10 20 30 40 50 100

PLATE XXVIII.—AMOUNT OF SEDIMENT IN LIME SULPHUR WASH MADE FROM LIME WITH DIFFERENT PERCENTAGES OF IMPURITY.

(White portions in cylinders show sediment; figures below plate indicate percentages of impurity in lime used.)

METHOD FOR APPROXIMATE DETERMINATION OF IMPURITIES IN LIME.

This test is based on the fact that when one part, by weight, of pure lime (calcium oxide, CaO) and two parts of sulphur are boiled with plenty of water for one hour, the lime and sulphur go into solution, only slight amounts of sediment being formed. If the lime contains impurities (oxides of magnesium, iron, aluminum, etc., and carbonate of magnesium, calcium, etc.), these do not go into solution but remain as sediment, together with any undissolved sulphur not acted upon because of an insufficient amount of pure lime, caused by impurities in the lime used. The amount of sediment thus formed can be utilized as a measure of the amount of impurities existing in the lime. The method, in brief, consists in making a lime-sulphur mixture on a small scale and measuring the sediment.

The apparatus required consists of (1) a granite-iron-ware deep vessel holding 1½ to 2 quarts, used for boiling the mixture in; (2) a spoon of the same material; (3) a glass cylinder about 2½ inches in diameter, 12 to 15 inches high. A cylinder graduated in cubic centimeters is the most convenient form. A plain cylinder, costing less, can be used but the column of sediment must be measured in inches and the diameter must be very nearly 2½ inches. Such cylinders can be obtained of Bausch & Lomb Optical Co., Rochester; and (4) a stick for stirring and measuring, on which is cut a notch at the point where the surface of the water stands when one quart of water is placed in the dish and the stick placed vertically in the water, one end resting upon the bottom of the dish.

The method of carrying out the test is as follows: Weigh carefully 2 ounces of the lime to be tested, place it in the boiling vessel and slake with water, adding the water gradually and being careful not to smother the lime with too much water. Stir with the spoon until the lime is thoroughly slaked and a thick, uniform paste or milk of lime is formed. Then add water enough

to fill to the notch on the stick, after which place over a fire and boil. Weigh 4 ounces of fine, high-grade flowers of sulphur and when the milk of lime begins to boil add the sulphur gradually, stirring in vigorously with the spoon. Allow the mixture to *boil gently* for one hour stirring most of the time to break up any lumps of sulphur, using the spoon or stick or both according to convenience and effectiveness. During the boiling, measure the height of the mixture about once every ten minutes by means of the notched stick and if the level of the liquid has dropped below the notch, add enough hot water to bring the level back to the notch. When the mixture has boiled one hour, let it cool and then, after stirring it up thoroughly with the spoon, pour quickly into the glass cylinder, being careful to get in all the sediment. Allow it to stand over night and then notice the height of the column of sediment by reading the number of divisions (cubic centimeters) at the upper surface of the sediment or by measuring with a rule. The percentage of impurities may be found by consulting the following table. In the third column is given for each percentage of impurity the number of pounds of lime that it will be necessary to use in making the lime-sulphur mixture by the Geneva formula:

Table XII.— PERCENTAGES OF IMPURITIES FOR DIFFERENT AMOUNTS OF SEDIMENT, AND AMOUNTS OF LIME TO USE.

Number of cubic centimeters of sediment.	Height of column of sediment in inches.	Percentage of impurities.	Number of pounds of lime to use to contain 36 pounds of calcium oxide
30	[illegible]	5	38
50	[illegible]	10	40
70	1	15	42
90	1¼	20	45
105	1[illegible]	25	48
120	1[illegible]	30	51

As previously stated, we strongly advise not using any lime that contains over 10 per ct. of impurities. The simplest way is to purchase lime of guaranteed composition, containing not less than 90 per ct. of pure calcium oxide and not over 5 per ct. of magnesium compound. The foregoing test can, however, be made use of whenever one is in doubt in regard to the purity

of the lime thus purchased or for testing a sample of lime previous to purchasing.

It is a matter of interest to notice the results obtained by applying this test to mixtures of pure lime (calcium oxide) and known amounts of magnesium oxide and calcium carbonate. The same results were obtained whether we used magnesium oxide or calcium carbonate as the impurity. In each case we used one quart of water and four ounces of sulphur and carried out the test in the manner already described, allowing the mixture to stand sixteen hours before measuring the sediment.

Table XIII.— RELATION OF AMOUNT OF IMPURITIES TO AMOUNT OF SEDIMENT.

Amount of pure lime used.	Amount of magnesium oxide or calcium carborate used.	Percentage of impurities on basis of 2 ozs. pure lime.	Cubic centimeters of sediment in glass cylinder.	Height of column of sediment.
0 oz.	2 oz.	100	350	5¼ inches.
1 "	1 "	50	180	2[illegible] "
1.2 "	0.8 "	40	150	2[illegible] "
1.4 "	0.6 "	30	120	1[illegible] "
1.6 "	0.4 "	20	90	1[illegible] "
1.8 "	0.2 "	10	50	[illegible] "

The results of these experiments are clearly shown in the accompanying illustration, for which the cylinders with their sediments were photographed.

This method can be used also in testing samples of sulphur as to suitability for making lime-sulphur solutions. One solution is made with a sample of sulphur known to be of high grade of purity and finely divided, using lime not less than 95 per ct. pure. A solution is thus made with each of the samples of sulphur to be tested, using the same lime. The test is carried out in each case in the manner described above. The amount of sediment is compared with that obtained in the first case; any increase of sediment over indicates impurities in the sulphur of particles too coarse to dissolve. The sediment should be examined carefully for the presence of coarse, yellow particles of undissolved sulphur which can be readily seen if present in appreciable amount.

THE FERMENTATION OF CITRIC ACID IN MILK.*

ALFRED W. BOSWORTH AND M. J. PRUCHA.

SUMMARY.

Citric acid, one of the normal constituents of milk, disappears during the souring of the milk. It is changed into acetic acid and carbon dioxide. *Bacterium lactis aerogenes* **is the only one of a number of common dairy bacteria tried which has the power of bringing about this change when present in pure cultures.**

INTRODUCTION

In September, 1908, while trying the method of Beau[1] for the determination of citric acid in milk the following figures were obtained:

Citric acid in fresh milk.....	0.21	gram per 100 cc.
Citric acid in sour milk.....	0.00	" " " "

In looking up the literature the following references were found:

Thorp's *Dictionary of Applied Chemistry* states that according to I. Macagno[2] citric acid disappears under the influence of bacteria, and acetic and propionic acids are formed.

Beilstein's *Handbuch der Organischen Chemie* states that sodium citrate and putrid flesh give carbon dioxide and butyric acid; that calcium citrate and a piece of old cheese give carbon dioxide, hydrogen and acetic acid; that calcium citrate fermented with beer yeast gives carbon dioxide, hydrogen, acetic and butyric acids; that calcium citrate and calcium carbonate with the water in which some hay has been washed give alcohol, acetic and succinic acids; and that citric acid is fermented by an extract of almond bran into carbon dioxide and acetic acid.

[1] *Rev. Gen. Lait.* **3:385** [2] *Gaz. Chem. Ital.* **11:443.**

*A reprint of Technical Bulletin No. 14.

EXPERIMENTS.

In order to repeat the first observations the following experiments were tried. Some fresh milk was obtained, to it was added a small amount of starter to hasten the souring, and it was then kept in the warm laboratory and determinations made as noted below.

Table I.— Disappearance of Citric Acid in Souring Milk.

Sample.	Age in hours.	Acidity of 100 cc. as $\frac{N}{10}$	Citric acid in 100 cc.
First experiment, 1	4	26.4 cc	0.224 gr.
First experiment, 2	15	40.0 cc	0.224 gr.
First experiment, 3	28	Curdled	0.224 gr.
First experiment, 4	35	Curdled	0.217 gr.
First experiment, 5	50	Curdled	0.053 gr.
First experiment, 6	60	Curdled	0.000 gr.
Second experiment, 1	12	20.0 cc	0.199 gr.
Second experiment, 2	36	84.0 cc	0.072 gr.
Second experiment, 3	60	Curdled	0.000 gr.

To 500 cc. of the whey (from the last experiment) containing no citric acid was added about 2 grams of calcium citrate, 200 cc. $\frac{N}{10}$ NaOH and water to make up to 1,000 cc. Determinations of citric acid on this mixture gave the following results:

	Acidity of 100 cc. as $\frac{N}{10}$	Citric acid per 100 cc.
Whey + calcium citrate when mixed	20.0	0.117 gr.
Whey + calcium citrate 24 hours old	30.0	0.000

In order to determine whether the citric acid could be fermented under conditions other than those presented in milk the following experiments were carried out.

In each of four flasks were placed 5 grams of calcium citrate and 500 cc. of bouillon containing 1 per ct. of lactose. The mixtures were sterilized and two flasks kept for checks. Into each of the other two flasks 1 cc. of buttermilk was introduced. The flasks were shaken every morning and evening. It was noticed that the calcium citrate in the flasks to which the buttermilk had been added was slowly going into solution. On the

twelfth day no insoluble citrate remained in the flasks. An examination of all the flasks showed checks to be sterile, the calcium citrate being still on the bottom of the flasks as an insoluble powder. Upon distilling with steam after acidulating with sulphuric acid, no volatile acid was found. The flasks to which the buttermilk had been added contained no insoluble citrate and upon testing were found to contain no citric acid in solution. Upon acidulating with sulphuric acid and distilling with steam a large amount of volatile acid was found which proved to be acetic acid by its forming acet-p-toluide, melting point 148° C.

In previous work it had been noticed that sour milk always contained volatile acid and we at once thought of citric acid as the source of some of it. In order to show that the volatile acids in sour milk increase with an increase of citric acid content the following experiment was carried out:

Some milk was divided into two portions; to one portion was added some calcium citrate, to the other nothing. The mixtures were allowed to stand fourteen days. When examined neither portion contained any citric acid. On acidulating and distilling with steam the following results were obtained:

Whey from milk .... 100 cc. gave 32.3 cc. $\frac{N}{10}$ volatile acid
Whey from milk to which calcium citrate had been added .... 100 cc. gave 45.7 cc. $\frac{N}{10}$ volatile acid

The acid proved to be acetic acid by forming acet-p-toluide, melting point 148° C.

In order to show that the acetic acid is derived from the citric acid and not from any of the other organic constituents of the milk a special solution was prepared. In this solution the citric acid was the only organic substance present as well as the only source of carbon.

An attempt was also made, with this solution as a medium, to study the action on citric acid of some common dairy bacteria in pure cultures.

Solution used to study action of bacteria upon citric acid:

Acid sodium phosphate (H_2NaPO_4)..........	5.0 Grams
Magnesium sulphate ($MgSO_4$)..............	5.0 "
Potassium chloride (KCl)..................	0.5 "
Ammonium citrate solution*...............	50.0 cc.
Water to make	1000.0 "

As a preliminary experiment, to see if the solution as made would sustain bacterial life, some flasks containing some of the solution were inoculated with sour milk and others with starter. At the end of eight days all the citric acid had disappeared in both cases and an abundance of acetic acid was found to be present. It was noticed that a gas was being given off during the fermentation. This was allowed to run into a solution of barium hydrate and found to be carbon dioxide.

Flasks were prepared containing 600 cc. of the solution, sterilized and inoculated with bacteria as noted in Table II. After standing twenty days they were examined. Those found to be pure cultures were tested. Results are noted below:

TABLE II.— EFFECT ON CITRIC ACID ON GROWTH OF DIFFERENT BACTERIA.

NAME.	Group No.	Action.
Bact. lactis aerogenes†..............	222.1113021	Citric acid completely broken down
" " *acidi*..................	222.2222033	No action on citric acid.
" " "	222.2222033	" " " " "
" " "	222.2222034	" " " " "
" " *aureum II*..............	222.2322533	" " " " "
" " "	222.2322533	" " " " "
Strt. lacticus..................	222.2222033	" " " " "
" "	222.2222033	" " " " "
" "	222.2222033	" " " " "
" *lactis citreus*..............	211.2223533	" " " " "
Micrococcus lactis varians...........	211.2223522	" " " " "
" " "	211.2223533	" " " " "
Checks.........................	....	" " " " "

* The citrate solution used is the one used for the determination of citrate-soluble phosphoric acid in fertilizers. (Bulletin 107, revised. Bureau of Chemistry, United States Department of Agriculture, page 1.) Fifty cc. of this solution will contain 8.457 grams of citric acid.

† All these cultures of bacteria were isolated from cheddar cheese. The duplicate cultures in the table were different strains of the same type.

The names of the cultures were adopted from the "Classification of Dairy Bacteria," H. W. Conn, W. M. Esten and W. A. Stocking. Ann. Report, 1909. Storrs Agricultural Experiment Station, Storrs, Conn.

Of the bacteria used, *Bact. lactis aerogenes* was the only one which fermented the citric acid. In order to determine the amount of acetic acid produced by this germ five-sixths of the contents of two flasks, each equal to 500 cc. of the original solution, were distilled with steam, after acidulating with sulphuric acid, until no more acid distilled over. This acid was found to be acetic acid by forming acet-p-toluide, melting point 148° C. The amounts distilled over were equal to 40.8 cc. normal acid in one case and 44.0 cc. in another.

Of the original solution 500 cc. contains 4.2285 grams of citric acid. If one molecule of citric acid yields two of acetic acid we should recover $\frac{120}{192}$ or ⅝ of the citric acid as acetic acid. Calculating the figures obtained from the distillates as acetic acid we have 2.448 grams in one case and 2.64 grams in the other. Five-eighths of 4.2285 is 2.6428.

The ability of these same organisms to attack the citric acid in milk was tested by adding them in pure cultures to flasks containing sterile milk. After two weeks at room temperature the citric acid had entirely disappeared from the flasks inoculated with *Bact. lactis aerogenes* but it apparently had not been attacked in the flasks containing the other organisms.

The action of *Bact. lactis aerogenes*, of *Bact. lactis acidi* and the mixed flora of buttermilk, upon the citric acid normally present in milk as well as citric acid when added in the form of calcium and ammonium citrates is shown in Table III:

TABLE III.— CITRIC ACID NOT CHANGED BY *Bact. lactis acidi.*

Flask No.	HOW INOCULATED.	Medium.	Action on citric acid.
1	1 cc. butter milk	600 cc. milk + 5 gr. calcuim citrate...	+
2	1 cc. " "	600 cc. skimmed milk + 10 cc. ammonium citrate	+
3	*Bact. lactis acidi**....	600 cc. milk	0
4	" " "	600 cc. milk 10 cc. ammonium citrate	0
5	" " "	600 cc. " 5 gr. calcuim citrate...	0
6	" " "	600 cc. skimmed milk 5 gr " "	0
7	*Bact. lactis aerogenes*.	600 cc. milk	+
8	" " "	600 cc. " + 10 cc. ammonium citrate	+
9	" " "	600 cc. milk + 5 gr. calcium citrate...	+
10	" " "	600 cc skimmed milk + 5 gr. " "	+

* This culture was the predominating germ in the butter milk used for inoculating bottles one and two.

After standing fourteen days an examination showed the bottles to be pure cultures with the exception of 1 and 2. These contained a miscellaneous growth. The citric acid, in the bottles to which had been added the buttermilk and *Bact. lactis aerogenes,* had all been fermented and an abundance of acetic acid was found.

It will be observed that the citric acid has been broken down in the presence of pure cultures of *Bact. lactis aerogenes* and a mixed culture from buttermilk.

Since *Bact. lactis aerogenes* is not to be expected in carefully made starter for butter making it would seem that the decomposition of the citric acid may be accomplished by other agents.[1]

In the process of cheese making the citric acid all disappears before the cheese is put in the press. One cheese examined gave the following results:

Milk used contained........	0.203	gr. citric	acid	per	100 cc.
Whey when drawn contained.	0.118	"	"	"	"
First whey from press contained..................	0.000	"	"	"	"
Curd when whey was drawn contained	trace				
Curd when put in press contained..................	0.00				

CONCLUSIONS.

1. During the spontaneous souring of milk the citric acid in it was changed into acetic acid and carbon dioxide.

2. Starter and buttermilk contained some agent capable of bringing about this change.

3. Of the several common dairy bacteria tried, *Bact. lactis aerogenes* was the only one found to have the power of fermenting the citric acid.

4. Citric acid when fermented by *Bact. lactis aerogenes* gave two molecules of acetic acid for every one of citric acid.

5. During the process of cheese making, and before the curd was in the press, the citric acid was all fermented.

[1] The search for the specific agents possessing this ability was not continued beyond this point as one of the authors (M. J. P.) was to be absent from the institution for a year.

THE ACIDITY OF GLUTEN FEEDS.*

W. H. JORDAN.

SUMMARY.

The marked acidity of certain gluten feeds, noted in the feeding-stuffs inspection of several states during the past three years, is due to the addition of "steep-water," a by-product obtained in the manufacture of corn products. The acidity of the "steep water" is due to its content of amido-acids and of phosphorus compounds with an acid reaction, probably mixed phosphates and phytates. Mineral acids are present only in negligible quantities.

NOTE.—The investigations herein reported were initiated and performed by E. L. Baker and A. W. Bosworth working somewhat independently of each other on different phases of the problem.—*W. H. J.*

INTRODUCTION.

During the years 1907 and 1908 it was noticed by chemists at several experiment stations, who have charge of the inspection of feeding-stuffs for their respective states, that many of the gluten feeds found upon the market showed a very high water-soluble acid content as measured by titration with phenolphthalein as an indicator.

At the Maine Station the soluble acidity was found as high as 1.93 c.c. $\frac{N}{10}$ per gram of feed.[1]

At the Massachusetts Station the soluble acidity was as great, in some samples, as 2.24 per ct. when calculated to sulphuric acid.

[1] Maine Sta. Bul. 156.

*A reprint of Technical Bulletin No. 16.

The suggestion was made[1] that this acidity might be due to phosphates.

At Geneva,[2] the soluble acidity was found to run as high as 0.91 per ct. when calculated to hydrochloric acid. At this Station it was noticed that the soluble acidity seemed to have some relation to the artificial coloring added and it was suggested that hydrochloric acid may have been used as a mordant for the coloring matter added.

Street[3] found acidity reaching 3.8 c.c. $\frac{N}{10}$ per gram of feed. He suggested that the acidity might be due to proteins or weak organic acids.

Mineral acids, if present in quantities indicated by the figures given above, would be very dangerous; and it became the duty of the experiment stations concerned to determine the cause of this acidity. This became necessary for two reasons: First, if the acidity should be found to be due to mineral acids the consumers should be warned; second, if the acidity should be found to be due to no dangerous ingredient, the fact would enable us to quiet the fears of many users of the feed who had become alarmed and had written the Station for advice.

Gluten feed is one of the products obtained in the manufacture of corn products. In 1893 a new process was patented whereby it became possible to combine more of the by-products, which had hitherto been thrown away, with the gluten feed. This process consists of the treatment of the "steep water" and its final addition to the gluten feed. A process of obtaining gluten feed is outlined by T. B. Wagner.[4] Part of this description is repeated here for convenience:

"The corn bought by us is of the No. 2 or No. 3 grades. To remove impurities, stones, dirt, dust, etc., the grain is passed through cleaning and separating machinery and the purified corn is then delivered to the steeping tanks, wherein it is soaked in

[1] Mass. Hatch. Sta. Bul. 128.
[2] N. Y. Stat. Bul. 303.
[3] U. S. Dept. Agr. Chem. Bul. 122.
[4] U. S. Dept. Agr. Chem. Bul. 122, p. 164.

warm water, slightly acidulated with sulphur dioxide. This treatment brings about a softening of the grain and facilitates the subsequent separation of the germ, which is effected after it has passed through a preliminary grinding whereby the corn is broken up and the germ set free. The balance of the material is now ground fine in Buhr mills, the coarser part, namely the bran, being separated by running the mass over silk sieves, while the starch liquor is concentrated and sent over slightly inclined planes, the starch tables, upon which, by a process of settlement and washing, the starch fills up in a solid layer. The lighter ingredients, gluten, fiber, etc., are carried off in the current of water over the end of the starch tables. We have thus obtained, first, the germ from which the well known corn oil and corn oil cake are obtained; second, the starch which furnishes the raw material for the corn starch of commerce and the manufacture of corn sirup and corn sugars; third, the bran, being the hulls of the kernel; and fourth, the gluten. The third and fourth, after repeated washings, are united, when still in a wet state, deprived of the largest part of the water by filter pressing, and delivered to the driers, when the water is reduced to approximately 10 per cent. The feed is now passed through grinding mills and reduced to a considerable degree of fineness.

"You will ask, and very properly so, 'What becomes of the mineral constituents of the corn and the soluble organic matter, which are extremely valuable as, for instance, the organic phosphorus compounds?' By far the largest amount of these constituents is leached out in the steeping of the corn. Were it desired only to recover the phosphorus salts, there would not be much difficulty involved in isolating them, but the steep water contains a large amount of other ingredients which greatly add to the food value of the gluten feed, such as albuminoids, sugar and other carbohydrates, potassium salts, etc., which, however, are hygroscopic and frustrate all efforts to recover them in dry form. Dr. Arno Behr devised ways and means of recovering these substances, which are fully described in United States Patent No. 491,234.

issued February 7, 1893. Briefly explained, Behr recovers these constituents of the corn by evaporating the steep water, after careful treatment, to a thick sirup, which contains these substances partly in solution and partly in suspension. This sirup is added to the feed, which latter forms an ideal absorbent." Behr's method, slightly modified, is the one used at present.

An analysis of gluten feed thus prepared is given by Wagner as follows:

	Per ct.
Water	10.36
Protein	25.95
Fat	2.18
Starch	18.09
Fibre	6.50
Ash	3.70
Nitrogen-free substance[1] (by difference)	32.22
Soluble in water (approximately)	15.50

Wagner omits any statement as to how the sulphur dioxide and sulphites are removed. This may be done by adding sulphuric acid, hydrochloric acid or a hypochlorite in chemically sufficient quantities to decompose the sulphites and expel the sulphur dioxide on boiling. It is claimed by the manufacturers that this treatment is not necessary, however, for the natural acidity of the steep water is sufficient to expel all sulphites present upon boiling.

From the preceding it is apparent that the steep water will contain that part of the corn which is rendered soluble during its treatment in the process through which it is passed. The normal soluble portion of the corn is increased, during the process, by the action of the sulphur dioxide upon the ash, and by its hydrolytic action upon the proteins. Without doubt a fermentation sets in which also acts upon the proteins.

The addition of the steep water to the gluten feed has been in practice for over fifteen years. The soluble acidity has been pres-

[1] Contains 17.18 per ct. pentosans.

ent during all this time but was not detected by inspection officials until recently. The manufacturers knew that the soluble acidity of their gluten feed was due to the steep water added and took steps to rectify it soon after the experiment stations began to investigate the matter, as is shown by the patent of Theodore E. Breyér (No. 920,108, May 4, 1909). This patent outlines a process for correcting the acidity of the steep water and then adding it to gluten feed.

CHEMICAL STUDY OF STEEP WATER.

Having ascertained that the soluble acidity of the gluten feed is due to the steep water added we took up a study of the steep water in order to determine what products it contained which would account for its acid reaction.

Two samples of steep water were very kindly sent to the Station by Mr. H. C. Humphrey of the Corn Products Refining Company:

Sample A, a steep water slightly concentrated.

Sample B, a steep water concentrated and ready to be mixed with gluten feed. The acidity of this steep water has not been neutralized.

TABLE I.— ANALYSIS OF STEEP WATER FROM CORN STARCH MANUFACTURE.

	A Grams per 100 cc.	B Grams per 100 cc.
Total solids	21.55	40.54
Total nitrogen	1.45	2.35
Nitrogen in form of amines:		
By tannic acid	0.99	1.85
By Van Slyke [1] amino-acid method	1.00	1.70
Nitrogen in form of NH_3	0.05	0.10
Sulphur	trace	trace
Chlorine	......	0.09
Total phosphoric acid	1.58	3.04
Organic phosphoric acid	0.94	2.18
Inorganic phosphoric acid	0.64	0.86
Ash	3.73	7.20
Potash	1.14	2.37
Sodium oxide	0.25	0.52
Magnesium oxide	0.67	1.04
Calcium oxide	trace	trace
[2] Acidity of 100 c.c.	55.0 c.c.[4]	108.0 c.c.[4]
[3] Acidity of 100 c.c. not neutral by boiling with an excess of calcium carbonate	....	65.0 c.c.
Specific gravity	1.0978	1.1374

Attention is called to the very low content of mineral acid and to the high content of amino nitrogen and organic phosphorus.

The following amino acids were identified by crystallization: Leucin, tyrosin, glutaminic acid, and phenylalanin.

The method used for the determination of inorganic phosphoric acid is the one given by Forbes, Lehman, Collison and Whittier.[5]

Upon examination the organic phosphorus was found to be combined in a manner indicative of the presence of phytin. Upon separation, and purification to some extent, an organic substance was obtained containing a very high percentage of phosphorus

[1] *Ber. deut. chem. Ges.* **43**: 3170–3181.
[2] Phenolphthalein used as indicator.
[3] Both samples contained reducing sugars and other carbohydrates.
[4] Normal acid.
[5] Ohio Sta. Bul. 215.

and having acid properties. Upon boiling this substance with strong nitric acid a large yield of inosite was obtained.

That phytin is a normal constituent of corn has been known for some time. Hart and Andrews[1] found that corn contains no inorganic phosphorus. They also found 0.177 per ct. of soluble organic phosphorus.

Hart and Tottingham[2] found no inorganic phosphorus in corn and 0.13 per ct. of soluble organic phosphorus which they identified as phytin.

It is easy to see, therefore, that the phytin in the corn, being soluble in water and weak acids, would naturally all go into the steep water during the treatment outlined in the first part of this paper. The inorganic phosphorus found would come from the breaking down of phytin due to the acid (sulphur dioxide) and heat used in the process and to any fermentation which might take place.

It was found impossible to make the steep water neutral to phenolphtalein by boiling 100 c.c. with 200 c.c. of water and an excess of calcium carbonate; 100 c.c. of steep water B had an acidity equal to 108 c.c. of normal acid. After boiling as stated above the acidity was found to be equal to 65.0 c.c. normal acid.

The amino-acids are capable of decomposing calcium carbonate. Acid phosphates are not capable of removing calcium from calcium carbonate in sufficient quantities to make phosphates neutral to phenolphtalein as is shown by the following:

One hundred c.c. of a solution of $Ca\,H_4\,P_2\,O_8$, having an acidity equal to 19.6 c.c. $\frac{N}{10}$ was boiled for ten minutes with one gram of calcium carbonate. The acidity was then found to be equal to 15.6 c.c. $\frac{N}{10}$.

One hundred c.c. of a solution of $K\,H_2\,PO_4$, having an acidity equal to 49.0 c.c. $\frac{N}{10}$ was boiled for ten minutes with 1 gram of calcium carbonate. The acidity was then found to be equal to 45 c.c. $\frac{N}{10}$.

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[1] N. Y. Sta. Bul. 238.

[2] *Jour. Biol. Chem.* **6**: 431.

Acid phytates, like acid phosphates, are not capable of removing calcium from calcium carbonate in quantities large enough to make phytates neutral to phenolphtalein, as is shown by the following experiment:

One hundred c.c. of a solution of acid phytates (calcium, magnesium and potassium phytates) having an acidity equal to 21.6 c.c. $\frac{N}{10}$ was boiled for ten minutes with 1 gram of calcium carbonate. The acidity was then found to be equal to 10.5 c.c. $\frac{N}{10}$. These facts are strong evidence that the greater part of the acidity of the steep water is due to the forms of phosphorus present.

We must conclude, therefore, that the acidity of the steep water is due to presence of two classes of compounds; nitrogenous bodies (mostly amino-acids), and phosphorus compounds (in all probability a mixture of phosphates and phytates).

EXAMINATION OF GLUTEN FEEDS.

Having determined that the addition of the steep water to gluten feed will very materially increase its soluble acidity, we next undertook a study of some samples of gluten feeds to determine, if possible, how much of the soluble acidity is due to the steep water added. The figures in the following tables are the results of our work.

The soluble constituents were extracted by adding five grams of the feed to 500 c.c. of water and shaking occasionally. The insoluble feed was filtered out and the water extract thus obtained used for the determination.

TABLE II.— ANALYSIS OF THE WATER EXTRACT OF SOME GLUTEN FEEDS.

SAMPLE NUMBER	Color of the water extract	Acidity of the water extract of 1 gr. as $\frac{N}{10}$	Total solids	Total ash	WATER SOLUBLE — Solids	Ash	Nitrogen	Nitrogen present as amines	Phosphoric acid	Organic phosphoric acid	Inorganic phosphoric acid	Sugar.
		Cc.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1	None	0.32	95.10	0.45	1.25	0.02	0.00	0.00	0.000	0.000	0.000	None
2	None	0.64	92.55	1.00	2.10	0.35	0.00	0.00	0.371	0.371	0.000	None
3	None	0.68	92.05	1.10	2.50	0.45	0.09	0.09	0.457	0.457	Trace	None
4	Light	2.19	91.95	1.85	5.90	1.05	0.32	0.32	0.603	0.497	0.106	+
5	Light	3.42	94.95	2.50	11.65	2.10	0.74	0.56	0.671	0.524	0.147	+
6	Medium	3.10	92.25	2.50	8.70	1.55	0.47	0.47	0.559	0.463	0.096	+
7	Medium	4.77	92.95	3.45	10.25	2.00	0.67	0.64	0.683	0.491	0.192	+
8	Medium	4.21	94.85	4.00	14.70	2.75	0.90	0.90	0.726	0.525	0.201	+
9	Heavy	5.72	93.25	3.45	13.90	2.35	0.97	0.95	0.794	0.584	0.210	2.13%
10	Heavy	4.50	92.70	4.30	18.00	3.20	1.08	1.04	0.878	0.571	0.307	2.92%
Bran	......	0.60	......	6.04	17.00	3.40	0.72	0.00	1.370	1.218	0.152	......

Sample 1 had no steep water added to it. The others, as shown by the figures, had received varying amounts of steep water.

Sulphur and chlorine were found to be present in traces only in some feeds and not at all in the rest. Acetic and lactic acids could not be detected.

An examination of Table II will show the following facts in connection with those feeds to which the steep water has been added.

1. The soluble solids are high.
2. They contain considerable soluble acidity.
3. The soluble nitrogen is high.
4. The soluble nitrogen is in the form of amines.
5. The total ash is high.
6. The soluble ash is high.
7. The soluble phosphoric acid is high.
8. The soluble phosphoric acid is mostly organic.
9. They contain sugars.

The presence of amines was determined in three ways.

1. Nitrogen not precipitated by phosphotungstic acid was determined. (The feeds contained no ammonia.)

2. Amines when acted upon by nitrous oxide give off free nitrogen.

3. The amines were crystallized and the following ones identified: Leucin, tyrosin, glutaminic acid, and phenylalanin.

The four amines identified are the ones produced in largest quantities from the hydrolysis of the zein of corn. The following table gives the percentages of these amines obtained from the hydrolysis of zein and the percentage of nitrogen in each.

	Amount in zein Per ct.	Amount of nitrogen contained Per ct.
Leucin	11.25	10.687
Tyrosin	10.06	7.735
Glutaminic acid	11.78	9.524
Phenylalanin	6.96	8.485

The inorganic phosphorus was determined by the same method used in examining the steep water. The organic phosphorus was found to be present in the same form as in the steep water. In Table III are given the results obtained from an examination of the samples of gluten feed collected, during the winter of 1908 and 1909, in connection with the State inspection of feeding stuffs.

TABLE III.—ACIDITY, COLORING MATTER AND FORMS OF PHOSPHORUS AND NITROGEN IN OFFICIAL SAMPLES OF GLUTEN FEEDS COLLECTED DURING THE WINTER OF 1908 AND 1909.

SAMPLE NO.	Acidity of the water extract from 1 gram as $\frac{N}{10}$	WATER SOLUBLE					Detection of artificial coloring matter by dyeing wool*
		Inorganic P_2O_5	Organic P_2O_5	Total P_2O_5	N	N as amines	
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
2607	0.0	0.00	0.00	0.00	0.03	0.03	Not colored.
2616	0.1	0.00	0.00	0.00	0.03	0.02	Not colored.
2670	0.1	0.00	0.00	0.00	0.03	0.02	Not colored.
2314	0.1	0.00	0.00	0.00	0.07	0.08	Not colored.
2337	0.1	trace	trace	trace	0.05	0.02	Colored.
2457	0.2	0.00	0.00	0.00	0.06	0.03	Not colored.
2508	0.3	0.00	0.00	0.00	0.20	0.15	Colored.
2352	0.3	trace	trace	trace	0.38	0.20	Colored.
2340	0.3	trace	trace	trace	0.19	0.02	Not colored.
2802	0.5	0.05	0.10	0.15	0.16	0.04	Not colored.
2701	0.6	0.06	0.09	0.15	0.10	0.07	Colored.
2326	0.9	0.30	0.03	0.33	0.40	0.36	Colored.
2655	1.0	0.14	0.07	0.21	0.33	0.31	Colored.
2329	1.3	0.37	0.39	0.76	0.89	0.72	Colored.
2659	1.3	0.26	0.09	0.35	0.76	0.54	Colored.
2549	1.4	0.30	0.14	0.44	0.68	0.63	Colored.
2476	1.4	0.34	0.08	0.42	0.67	0.62	Colored.
2324	1.4	0.59	0.16	0.75	1.12	0.89	Colored.
2460	1.5	0.29	0.16	0.45	0.69	0.59	Colored.
2561	1.7	0.41	0.16	0.57	0.84	0.72	Colored.
2302	1.8	0.41	0.27	0.68	0.67	0.62	Colored.
2662	1.8	0.34	0.13	0.47	0.64	0.48	Colored.
2301	1.9	0.48	0.30	0.78	0.93	0.84	Colored.
2389	2.5	0.23	0.23	0.46	0.83	0.71	Colored.
2304	3.5	0.52	0.63	1.15	1.21	1.04	Colored.

*Method of Sostegni and Carpentini. U. S. Dept. Agr. Chem. Bul. 107 (revised).

The figures in this table very strikingly bring out the connection existing between the acidity of the water extract and the phosphorus and nitrogen compounds present in the feed in soluble forms.

The table also seems to establish a relation between the acidity and the presence of artificial coloring matter.

The manufacturers explain the presence of artificial color by saying that when white corn is used the feed must be colored in order to meet the prejudiced demand for a yellow colored gluten feed, and that steep water when added to gluten feed reduces the richness of the color and necessitates artificial coloration to meet the demand.

That the amount of coloring matter added is proportionate to the amount of steep water added is shown by Table IV.

TABLE IV.— ACIDITY AND COLOR OF OFFICIAL SAMPLES OF GLUTEN FEEDS COLLECTED DURING THE WINTER OF 1909 AND 1910.

Sample No.	Acidity of the Water extract from 1 gram as $\frac{N}{10}$	Color of Water Extract
2847..	0.1	colorless
2808..	0.2	colorless
2989..	0.2	colorless
2834..	0.3	colorless
2836..	0.3	colorless
3113..	0.3	colorless
2853..	0.4	very faint (yellowish)
2883..	0.4	very faint (yellowish)
2810..	0.6	very faint (yellowish)
2814..	0.6	very faint (yellowish)
2890..	0.6	very faint (yellowish)
2807..	0.8	colorless
2938..	0.8	faint yellow
2905..	1.2	yellow
2729..	1.6	straw color
2958..	1.7	deep orange
2825..	1.8	yellow
2967..	2.0	deep orange
2988..	2.2	deep yellow
2998..	2.2	yellow
2720..	2.5	straw color
2806..	2.8	straw color

It is seen from the data presented that the soluble portion of the gluten feeds is composed of carbohydrates, amines, phytates and phosphates. No mineral acids are present in more than traces, and they can be dropped from further consideration.

In conclusion it can be said that the soluble acidity of gluten feeds is caused by the addition of steep water and that the acidity of the steep water is due to the presence of amino-acids, phytates and phosphates.

CONCLUSION.

1. The acidity of gluten feeds is caused by the addition of "steep water," a by-product obtained in the manufacture of corn products.

2. The "steep water" contains two classes of compounds which give it an acid reaction. There are, amino-acids and phosphorus compounds. These phosphorus compounds are probably a mixture of phosphates and phytates.

3. The "steep water" contains traces of mineral acids (acids of sulphur and chlorine). They are present in such small quantities that they need not be considered as imparting any deleterious properties to the feed when the "steep water" is added to it.

REPORT

OF THE

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REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

EXPERIMENTS WITH HOME-MADE CONCENTRATED LIME-SULPHUR MIXTURES.*

P. J. PARROTT AND W. J. SCHOENE.

SUMMARY.

This bulletin deals with the use of home-made concentrated lime-sulphur mixtures in various Station experiments during the past three years and in seventeen volunteer experiments conducted during 1910.

In the Station experiments of 1910 the densities of the clear solution in twenty-one preparations varied from 22° to 31°B., giving an average of 26 1-2°B. The sediment in eight samples that were analyzed ranged in quantities from 2.9 lbs. to 21.4 lbs. per barrel. The cost of materials to make a barrel of concentrate was about $3.05 according to the formula.

The home-made concentrates when used at effective strengths, as determined by hydrometer tests, have given, in the Station experiments for the past three years, efficient results on the San José scale and blister-mite.

In the volunteer experiments the densities of the mixtures ranged from 22° to 32.9°B. The cost of materials to make a barrel of concentrate was from $2.10 to $3.50. The amounts of clear solution and sediment varied considerably but, in the main, preparations of satisfactory densities with moderate amounts of sediment were obtained.

Of eleven volunteer experiments on blister-mite there are ten reports of satisfactory results by the use of the home-made concentrate and one report of failure. Of seven experiments on San José scale there are five reports of efficient control and two reports of partial success, due probably to difficulties in spraying large trees or to the use of mixtures of too low densities. The

*A reprint of Bulletin No. 330.

results on scale emphasize the necessity both of thorough spraying and of using diluted mixtures of efficient strengths to obtain uniform results on this pest. There are four reports on spraying with arsenate of lead in a lime-sulphur solution for the codling moth which are inconclusive because of the conditions of the experiments.

Very dilute mixtures of the home-made concentrate have on the whole proven fairly safe on apple foliage. In a number of orchards slight injuries were noticed on the more tender leaves, especially following the spraying after blossoming. These injuries were generally obscured by the new growth in from seven to ten days. Damages of a more serious nature occurred in a few orchards. Dropping of fruit and leaves are noted in one experiment. Nearly all reports note relative absence of russeting of apples on trees sprayed with home-made concentrate. Of the seventeen fruit growers who have reported these experiments all have expressed their intentions to use lime-sulphur solution for summer spraying of apples.

The investigations of the Department of Chemistry have shown the desirability of changing the formula for making a home-made concentrate. A new formula is proposed which is as follows: Lump lime (pure lime, CaO, used as basis), 36 lbs.; sulphur, 80 lbs.; water, 50 gals.

The chief advantages secured by this formula are a more economical use of spraying supplies and reduced amounts of sediment.

INTRODUCTION.

This bulletin summarizes the results of various spraying tests by the Station and of a number of volunteer experiments during the past spring with the home-made concentrated lime-sulphur mixture. One feature of the commercial brands that especially impresses fruitgrowers is the greater convenience in the handling of concentrated solutions as compared with the ordinary lime-sulphur wash. Unlike the latter wash, the proprietary preparations may be used cold. They are storable and therefore avail-

able for use at one's convenience, and they are free from clogging sediment. Such differences are manifestly striking. For reasons of convenience and of possible economy, the question is frequently asked by fruitgrowers if it is practicable for them to make their own concentrate. As several formulas for preparing the concentrated lime-sulphur mixtures have been published, the Station encouraged a number of fruitgrowers to test them this spring, and thus decide for themselves as to the practicability of making such preparations. It was thought that their experience would be a safe indication as to what other fruitgrowers with similar spraying problems could likewise accomplish.

STATION EXPERIMENTS WITH HOME-MADE CONCENTRATED SOLUTIONS.

CONTROL OF THE SAN JOSÉ SCALE.

Since 1902, the Station orchards have been sprayed each year with the lime-sulphur wash for the purpose of controlling the San José scale. The wash was prepared by the common method until the spring of 1908, when Prof. A. B. Cordley * published a formula for making a concentrated lime-sulphur solution. The Station has since gradually discontinued the former practice of making this spray, and now uses in preference its own concentrated mixtures. There was at first some question as to the advisability of making this change for fear that the concentrated preparations, because of their variableness in densities of the clear liquid and amounts of sediment, might not prove efficient remedies for the scale; but during the three years in which they have been employed no difference in their effectiveness against this pest has been apparent, as compared with the results obtained in previous years' spraying with the common wash. Were they possessed of less efficient properties, any deficiency would have been indicated during this period by an increased infestation of the wood and fruit. Such has not been the case. While an

* *Rural New Yorker*, 67:202. March 7, 1908.

occasional tree shows some evidence of the breeding of the scale, specimens of fruit blemished by this insect are very seldom found. In various experiments with home-made and commercial concentrates in badly infested orchards that are adjacent the results on the scale have been similar. The protection thus afforded to the fruit crops from spotting by the scale would seem to have safely established the effectiveness of the home-made concentrate for this pest.

HOME-MADE CONCENTRATE FOR BLISTER-MITE.

An application of a sulphur wash as buds are bursting affords efficient protection to apple trees from the blister-mite. In many tests with the common lime-sulphur wash, proprietary preparations and the home-made concentrate, there has been no appreciable difference in the effectiveness of these various sprays on the mite, when they were used at proper strengths and under similar conditions.

SUMMER SPRAYING WITH THE HOME-MADE CONCENTRATE.

The experience of this year indicates an extensive use of sulphur sprays for the treatment of trees in foliage, especially for varieties that are susceptible to russeting of the fruit by bordeaux mixture. If the value of the sulphur spray best suited for this purpose depends on the chemical union of the lime and sulphur, rather than on a mechanical mixture of these materials, there is no apparent reason why the home-made concentrates cannot be used for all purposes for which commercial solutions may be safely employed. During the season of 1910 a concentrate of our own manufacture was used almost exclusively for the summer treatment of apples, pears and plums on the Station grounds and for the spraying of apples in two adjacent orchards. These operations were designed to obtain data as to the comparative insecticidal and fungicidal properties of various sulphur sprays and bordeaux mixture, and as to the practicability of combining common spraying arsenicals with lime-sulphur mix-

tures. In the comparative tests of the home-made concentrate with proprietary preparations there has been no apparent difference in the results on foliage or in their effectiveness on various fungi and insects. Because of the promising results in most cases, the home-made concentrate will again be tried next year for summer as well as for the dormant spraying of apple orchards under Station management.

VARIATIONS OF THE HOME-MADE CONCENTRATE DURING 1910.

During the spring of 1910 twenty-one barrels of the home-made concentrate were made for the Station experiments. The densities of the clear solution for the entire number of the preparations varied from 22° to 31° B., giving an average density of 26½° B. Samples were taken to ascertain the relative amounts of insoluble materials in the mixtures, and in eight analyses the variation in the sediment was from 2.9 lbs. to 21.4 lbs. per barrel.

ADVANTAGES OF CONCENTRATED MIXTURE OVER THE COMMON WASH.

The home-made concentrated lime-sulphur mixture possesses several advantages over the wash as commonly made. To be noted especially by fruitgrowers not owning a cooking plant is the small outlay that need be expended for a cooking outfit of sufficient capacity to meet the requirements of the average orchardist. Iron kettles have answered the purposes of many fruitgrowers in preparing the concentrate. Those who have in the past disliked to prepare a lime-sulphur wash in kettles do not entertain the dislike to the same degree in making concentrated solutions, since a barrel of the concentrate, even of rather low density, will make several times its volume of a diluted spraying mixture of efficient strength. Those who already have cooking plants, equipped with steam, are required to make fewer boilings, thus reducing the operating expenses. If the concentrated solution is well made there is no coarse sediment to clog nozzles, and to cause the rapid wearing out of the packing, lining

and other parts of the pump. As the concentrate may be kept in tight containers with comparative freedom from crystallization, even in prolonged storage, it may be made whenever convenient and used as occasion requires. The steps required in preparing the concentrated solution do not differ materially from those in preparing wash by the method familiar to many of our fruit-growers.

DIFFICULTIES IN MAKING THE CONCENTRATED SOLUTION.

The principal difficulties that the Station has experienced in making lime-sulphur solutions are to obtain preparations of fairly high densities and to avoid large amounts of sediment. The different boilings have always varied in degree of concentration and in the quantities of the sediment. These difficulties have now been largely overcome by a vigorous boiling of the entire volume of the wash for an hour, with frequent stirring, and by the employment of clean lump lime, free from air-slaked material, which tests at least 90 per ct. calcium oxide and is practically free from magnesium compounds. The density of the clear solution during the past season usually ranged between 25° and 31° Beaumé, and because of the variation the use of a hydrometer is always necessary in order to determine the strength of the diluted mixtures. With the new formula that is now recommended (see page 481) fruitgrowers while obtaining mixtures of somewhat lower densities should be able to obtain larger quantities of the clear, reddish liquid, and little or none of the gritty or pasty sediment and but small amounts of the light, flocculent precipitate, which will usually pass through an ordinary strainer.

COST OF THE HOME-MADE CONCENTRATE.

The actual economy in making one's own concentrated lime-sulphur mixture is not generally understood. It is, in fact, somewhat less than is usually supposed. The reason is that the home-prepared mixtures, besides containing more or less amounts of sediment, are usually lower in density than the commercial

brands, and consequently do not make as many gallons of diluted spray of a given strength. In estimating the difference in cost between a home-made concentrate and a commercial lime-sulphur solution, the variation in density of the clear liquid and in the amount of sediment should be taken into consideration. The accompanying table, based on mixtures used in experiments at the Station, shows clearly the apparent and real saving by making the home-made concentrate.

TABLE I.— COST OF HOME-MADE AND COMMERCIAL CONCENTRATES.

KIND OF MIXTURE	Amount of mixture: Number of gallons clear solution	Amount of mixture: Number of pounds of sediment	Volume* of mixture not clear	Density of clear solution	Number of gallons of diluted mixtures testing 4.5° B	Comparative values by percentages	Cost of materials, labor, etc. per barrel	Cost of mixture to equal fifty gallons of solution testing 33° B
			Per ct.	*Degs. B.*				
Commercial solution.......	50	0	00	33	450	100	$9 00	$9 00
Home-made concentrate 1..	48.5	19.2	32	27	339	75	†3.05	4.07
" " 2..	48.4	21.4	57	28.4	363	80	†3.05	3.81
" " 3..	49.5	9.2	48	26.6	339	75	†3.05	4.07
" " 4..	49.4	9.9	25	27.6	380	84	†3.05	3.63

†Formula:

Sulphur, 125 lbs	$2.35
Lime, 60 lbs.	.40
Labor, fuel, etc	.30
Total cost.	$3.05

* These figures showing the relative volumes of sediment in suspension are based on samples that were allowed to settle for twenty-four hours. It will be observed that notwithstanding the volume in suspension the actual amount of dried sediment by weight is only a small percentage of the total product of the mixture.

VOLUNTEER EXPERIMENTS.

For the purpose of making available the experience of various orchardists in preparing concentrated lime-sulphur mixtures and to show what they have accomplished as a guide for others in similar efforts, it was thought desirable to include in this bulletin a discussion of these operations. These are designated "volunteer experiments" as they have been largely planned and carried out by the fruitgrowers themselves. To them belongs the credit — not to the Station. In compiling these experiments, the facts have been stated precisely as they were given to us; and for

purposes of accuracy a copy of the manuscript discussing his experiment was also furnished to each orchardist for correction and approval.

For the sake of brevity the reports have been much condensed, but as far as possible the more important items needed to convey a fairly accurate description of the conditions and results of the experiments are given. The experiments are designated by numbers and are arranged in the order of their location, commencing with Niagara County and continuing through the leading apple-growing counties of western New York to the Hudson Valley.

EXPERIMENT NO. I.

S. S. Hopkins, Youngstown, prepared the concentrated lime-sulphur solution principally to combat the San José scale. The diluted spray was composed of one gallon of the concentrate testing 28° B. diluted with six or seven gallons of water. The materials to prepare the mixture were ground brimstone, and lime with a guaranteed analysis of 95 per ct. calcium oxide and practically free from air-slaked materials. The mixture was cooked by direct steam, using the formula: Lime 65 lbs. and sulphur 125 lbs. In starting the wash to cook, the lime and sulphur were first added to enough boiling water to slake the lime. After the lime had slaked, the full amount of water was added and the wash was boiled for an hour. The average density of 20 batches was 28° B. In none of the boilings did an excessive amount of sediment occur, and there was on an average about 3 gallons of sludge and 2 gallons of coarse, or pasty, unsprayable material to each batch. By using a steam cooking outfit about 9 barrels of concentrate were made in a day at a cost per barrel of about $2.55 for materials and 33 cents for labor. The concentrate was stored in oil barrels for an average of six days. One lot of 20 gallons was kept in an open cask for seven days, covered with oil. Mr. Hopkins thinks that the preparation of a concentrate is more convenient than making lime-sulphur wash by the old method, as much more mixture can be made at each boiling and there is not the trouble with crystallization of the solution upon cooling.

Results on scale.— The scale was efficiently controlled and apparently there was no appreciable difference in the effectiveness of the concentrated solution and the ordinary lime-sulphur wash upon this pest. Because of the favorable reports on lime-sulphur solutions as foliage sprays, it is intended during the coming year to use the home-made concentrate for the summer treatment of a portion of the apple orchards.

EXPERIMENT NO. II.

Asa Baldwin, Lockport, made the concentrated mixture and used it at a strength of 4½ to 5° B. as a dormant spray for the San José scale. The materials used were light sulphur flour and lime purchased from the following three sources: Niagara County, Ohio and Pennsylvania. The first three boilings were with steam, using Niagara County lime 50 lbs., sulphur 100 lbs. and water 50 gals. At the end of the cooking the volumes had increased to 56 or 58 gallons of mixture which tested from 20° to 22° B. These preparations consisted largely of clear liquid, with very little sediment, all of which was sprayable. The next two barrels were made in a kettle, using Ohio lime, the formula being lime 65 lbs., sulphur 125 lbs.; and at the end of the cooking there were about 52 to 54 gallons of liquid which tested about 26° B. These mixtures seemed to have more fine, greenish sludge, but all of it passed nicely through the nozzles, forming a heavy coating on the trees. The last two barrels were made with Pennsylvania lime 65 lbs. and sulphur 125 lbs. This lot was cooked by kettle and tested 26° B. These mixtures were darker and thicker than the others, and contained very little clear liquid. There was only about one gallon of coarse sediment per barrel, which consisted mostly of small lumps of sulphur. Four barrels of concentrate were made in a day, costing per barrel for materials $2.65 if Niagara County lime and sulphur 100 lbs. were used and about $3.50 if Pennsylvania lime and sulphur 125 lbs. were used. The cost of labor was about 50 cents per

barrel. The material was stored in barrels which were purchased of a local dealer.

Results on scale.— Applications of the concentrated solution gave entirely satisfactory results in controlling the scale on apples and pears. It is planned to use the concentrate next year as a summer spray because apples were badly russeted this season by bordeaux mixture.

EXPERIMENT NO. III.

A. H. Ernest, Lockport, prepared the home-made concentrate according to the formula, lime 50 lbs., sulphur 100 lbs., and water to make 50 gallons of mixture. The lime was fresh lump lime, with a guaranteed analysis of 95 per ct. calcium oxide. The sulphur was commercial ground brimstone. The mixture was cooked by direct steam. In each boiling there was an average of about forty-eight gallons of liquid, one and a half gallons of sediment, and a half-gallon of unsprayable material. The range of densities of the clear liquid was 28° to 33°, averaging about 31° B. From nine to ten barrels of concentrate were made in one day at a cost of $2.60 per barrel, allowing $2.30 for spraying supplies and 30 cents for labor. The preparations were contained in barrels purchased from local dealers. A concentrate of reasonably high density is regarded as not difficult of attainment.

Results on leaf curl.— Applications of diluted mixtures testing about 4.5° B. gave excellent results in the protection of peach foliage from this disease.

Results on apple scab.— The results of spraying for this disease were uncertain, as there was an almost complete failure of the apple crop. Applications of the diluted spray, testing about 1.5° B. just after blossoming caused considerable injury to the foliage of a number of apple trees, while the larger portion of the orchard was unaffected. It is planned to employ the home-made concentrate next year for San José scale and blister-mite, and for future summer spraying.

EXPERIMENT NO. IV.

F. W. Paine, Medina, made the concentrated lime-sulphur solution for the special purpose of controlling the San José scale, blister-mite and peach leaf-curl, and for some experimental tests to determine its effect on foliage and its value as a preventive of apple scab. The concentrate was prepared according to the formula: Lime 55 to 60 lbs., sulphur 110 lbs., and water to make 50 gals. of mixture. The spraying supplies were commercial sulphur flour, and lime guaranteed 98 per ct. calcium oxide. The preparations were cooked in an iron kettle of 70 gallons capacity. Samples of different boilings, taken in glass jars, indicated that about four-fifths of the mixture consisted of clear liquid. The density of the solution ranged from 26.5° to 29.5°B., averaging about 28.5°B. A large amount of sediment occurred in only one boiling, when about one-third of the mixture was dark colored. There was in none of the preparations any unsprayable material. The concentrate was kept in an entirely satisfactory condition in oil barrels from four to five weeks. From one to four barrels of mixture were made in a day at odd intervals during the rainy season. A barrel of the concentrate cost approximately $2.90, allowing $2 for the sulphur, 40 cents for lime and 50 cents for labor. No serious difficulties were encountered in making the preparations, and it is planned to use the home-made concentrate in the future. To control the scale and blister-mite the concentrate testing 28.5° B. was diluted with seven gallons of water, and for foliage treatment a gallon of the mixture was used to about twenty-eight gallons of water.

Results on scale.— The scale was held in check, but the results as a whole were not as satisfactory as desired. It is believed that the fault lay in diluting the concentrate with too much water, although the difficulties in spraying large apple trees thoroughly may have been largely responsible for the partial failure.

Blister-mite.— This pest was satisfactorily controlled.

Leaf curl.— There was practically none of this disease on sprayed trees.

Apple scab.— There was very little scab on the leaves and only a slight amount of spotting of the fruit. In general the condition of the trees was satisfactory for the crop was never more free of scab or the foliage more thrifty. The occurrence of scab was attributed to the interlacing of the branches of the trees and lack of pruning which, in some instances, made thorough spraying almost impossible. The spraying after blossoming caused slight burning of the leaves, especially on those portions of the trees where the applications were the heaviest. The damage became less conspicuous with each succeeding day and was hardly noticeable after a period of ten days. On account of these injuries more dilute mixtures will be used for future summer spraying. There was slight russeting of apples which was however not much more conspicuous than that occurring on unsprayed trees. Pears appeared to be more susceptible to injuries of foliage than apples. On account of its cheapness and the satisfactory results in general on insects and fungi, the lime-sulphur solution is preferred to bordeaux mixture, and next season it will be relied on entirely for summer spraying of apples and pears.

EXPERIMENT NO. V.

A. J. Skinner, Medina, prepared the concentrated lime-sulphur solution for the special purpose of controlling the blister-mite. The diluted spray was applied at a strength of one gallon of the solution, testing 32° B., diluted with eleven gallons of water. The materials for making the mixtures were commercial brimstone, and lime guaranteed 95 per ct. pure. The preparations were cooked in an iron kettle of 70 gallons capacity, and they varied in density from 29° to 32° B. Sediment was present in large quantities in the first boiling, and because of its abundance the proportions of the lime and sulphur were varied. The best results were obtained by using the formula: Lime 65 lbs., sulphur 100 lbs., and water 65 gals. By using this formula there was on an average about twelve gallons of blackish sediment of varying consistency, nearly all of which was sprayable. No analysis was made of the lime, but the occurrence of the sediment would sug-

gest that the lime was of a rather inferior quality. The cost of making a barrel of concentrate was estimated at about $2.70, allowing $2.20 for the spraying supplies and 50 cents for labor. Vinegar barrels purchased from local grocers were used to contain the concentrate, which kept in a satisfactory condition during a short period of storage. Because of the economy and comparative ease of making solutions of fairly high densities, it is planned to employ the home-made concentrate for future spraying.

Results on blister-mite.— Trees sprayed with the lime-sulphur solution showed no appreciable evidence of the work of the blister-mite. The lime-sulphur solution is preferred to bordeaux mixture for the summer spraying of apples.

EXPERIMENT NO. VI.

G. D. Simpson, Carlton, used his own concentrated lime-sulphur solution testing about 29.5° B for blister-mite at the rate of 1 to 9, and as a summer spray at 1 to 25, 1 to 33 and 1 to 40. The materials used were ground brimstone, and lime which was purchased with a guarantee of 95 per ct. of calcium oxide. The lime consisted of clean lumps, practically free from air-slaked material. The wash was prepared in a 75-gallon kettle. The proportions of lime and sulphur were varied respectively as follows: 50 to 100, 57½ to 115, 60 to 120, 60 to 125, and 50 gallons of water was used in each case. The mixtures after boiling were about two-thirds clear solution, which in four batches gave an average density of 29.5° B. Each batch contained about a pint of unsprayable material composed of undissolved sulphur and grit from the lime. The mixture was stored in oil barrels, and a quantity of it was kept for six months or more in storage in a satisfactory condition. With sulphur at $1.78 per cwt. and lime at $1.35 per barrel the cost of materials for a barrel of concentrate was $2.50. A barrel of the concentrate was made by one man in two hours. The method of preparing the wash that gave the most satisfactory results was to heat 10 gallons of water in the kettle, then add the sulphur and stir to break up the lumps. Half the lime was then used,

the mixture being stirred while the lime was slaking, and sufficient water was poured in to keep the wash in a thin, pasty condition. The remainder of the lime was used as soon as the slaking of the first amount was completed. The full quantity of water was added as soon as all the lime had slaked and the entire mixture was boiled until it turned to an amber color. The first application of the lime-sulphur solution, 1 to 9, was made as the buds were opening, for the special purpose of destroying the blister-mite. A second treatment was given just before blossoms opened, using the concentrate at 1 to 33, with 2½ pounds of arsenate of lead to a barrel of the diluted spray. After the blossoms dropped there was a third spraying at a dilution of 1 to 40, with arsenate of lead. Two weeks later a fourth application of 1 to 25, containing arsenate of lead, was made from the east side of nine rows of apples, and on account of interference by rain the remaining four rows of the orchard were not sprayed till one week later.

Results on blister-mite.— The foliage was practically free from blister-mite as a result of this treatment and spraying during the previous year with the lime-sulphur wash.

Green aphis and woolly aphis.— There was no evidence that the various applications of the sulphur solution had any appreciable influence on the numbers of these insects.

Apple scab.— The crop showed practically no evidence of this disease throughout the summer, but during the latter part of September there was a slight amount of scab on some varieties. The Baldwins produced the largest and cleanest crop ever grown in the orchard. There was very little russeting of the fruit. There was, however, a slight burning of the foliage by the second treatment, while the spraying to complete the last application caused considerable burning of both fruit and foliage, resulting in a loss of about two-thirds of each. According to present plans it is intended to use the lime-sulphur solution, containing arsenate of lead, for the summer spraying of apples.

EXPERIMENT NO. VII.

George B. La Mont, Albion, prepared the concentrated solution to combat the blister-mite and as a foliage spray for apple scab. The materials employed in making the mixture were sulphur flour and lime guaranteed 95 per ct. calcium oxide. The wash was cooked in a kettle, the formula being lime 37 lbs., sulphur 75 lbs. and water 55 gallons. At the end of the boiling about 40 gallons of liquid were obtained which gave an average reading on the hydrometer for nine cookings of 26¾° B. At no time was there an excessive amount of mud or sediment, and usually there was about one-half gallon of unsprayable material to each 50 gallons of concentrate. With one kettle about two barrels of concentrated mixture could be made in a day at a cost per barrel of $2.25 for supplies and $1.50 for labor. The mixture was stored in barrels purchased from a local hardware dealer.

Results on blister-mite.— Spraying for the mite gave very good results.

Apple scab.— The applications of the lime-sulphur solution were efficient preventives of apple scab. There was in no instance any evidence of burning of the foliage, and it is believed that there was no spray injury of apples, although where the solution was used 1 to 40, some of the fruit showed slight russeting. Wherever bordeaux mixture was used apples were very badly russeted. Chief reliance will be placed on sulphur sprays for foliage spraying of apples.

EXPERIMENT NO. VIII.

B. L. Perkins, Albion, made his own concentrated lime-sulphur mixture and applied it in the proportions of one gallon of the solution, testing about 30° B., diluted with eleven gallons of water, to control blister-mite on apples and leaf curl on peaches. More diluted mixtures were also used for the treatment of trees in foliage. The materials to make the wash were sulphur flour, and lime purchased with a guarantee of 95 per ct. purity. The wash was boiled in a kettle and five batches were made after the

formula: Lime 50 lbs., sulphur 100 lbs. and water 50 gallons. The average density of the preparations was 29.6° B. There was not more than a gallon of thick sediment in any of the mixtures, and only a pint to a quart of unsprayable material, which was much less than was present in a commercial mixture that he had used in the past. The preparations were made just a few days before the spraying season and were kept in a satisfactory condition in storage. With one kettle, four barrels of concentrate were made in a day, at a cost per barrel of $2.18 for materials and 50 cents for labor. The barrels used for storage were molasses barrels purchased from a local grocer at 75 cents each. The only difficulty experienced by Mr. Perkins was in completely dissolving the sulphur and thus reducing the amount of insoluble materials in the sediment. He believes that in making his own preparations he has saved several dollars on each barrel of concentrate.

Results on blister-mite.— Apple trees were almost completely free from injuries to foliage by this pest.

Peach-leaf curl.— There was very little evidence of this disease, except on portions of an occasional tree which was perhaps not thoroughly sprayed.

Apple scab.— The fruit showed only slight indications of this disease, and there was much less spray injury of apples as compared with trees treated with bordeaux mixture. The home-made concentrate will largely be depended on for the future, for dormant treatment as well as for summer spraying.

EXPERIMENT NO. IX.

L. R. Rogers, Albion, used concentrated lime-sulphur of his own manufacture for blister-mite, leaf curl and apple scab. This was applied for dormant treatment at the rate of 18 gallons of a solution testing about 30° B. to a 200-gallon tank, and as a foliage spray at a strength of 8 gallons of the solution testing 29½° B. to a 200-gallon tank. The materials used in the preparation of the wash were commercial sulphur flour and lime guaran-

teed to contain 95 per ct. calcium oxide and not over 2 per ct. magnesia. It was practically free from air-slaked lime. The wash was cooked in a kettle, and the formula used was lime 50 lbs., sulphur 100 lbs. and water to make 55 gallons of mixture. The results of a number of boilings were as follows: Lot No. 1 boiled less than one hour, no coarse sediment but solution not entirely clear, density of clear solution 30¼° B.; Lot No. 2 boiled over one hour, no coarse sediment, clear solution held in suspension some flocculent material, density of clear solution 30° B.; Lot No. 3 boiled 1¼ hours, clear solution with hardly any sediment of any kind, density of clear solution 29° B. None of the mixtures were strained as all the material was sprayable. One lot was stored in open barrels for two days without crystallization, while another lot was stored for a week in an open barrel with formation only of a paper-like sheet of crystals over the top. Two barrels of concentrate were made in a half of a day at a cost per barrel of $2.13 for materials and 50 cents for labor.

Results on blister-mite.— The spraying did not give satisfactory results in controlling the work of the mite. This failure was not laid to any deficiency in the concentrated solution but was attributed to the lateness of the application.

Leaf curl.— Peach trees were sprayed first with bordeaux mixture and again a few days afterward with lime-sulphur solution with completely satisfactory results on leaf curl.

Apple scab.— Apple trees were sprayed once after the blossoms dropped, with the lime-sulphur solution, but later treatments were with the bordeaux mixture. Apple scab on the leaves was not controlled as satisfactorily as was desired. It is intended to make next year much larger quantities of the home-made concentrate for spraying during early spring of all varieties of fruits and for the summer treatment of apples.

EXPERIMENT NO. X.

Bert H. Henion, Brockport, made the concentrated lime-sulphur mixture and employed it largely to combat the blister-mite and for summer spraying for apple scab and codling moth. The

solution was applied to dormant trees at a strength of 3½° to 4½° B., while for foliage treatment the concentrate testing 31° B. was diluted with thirty or forty parts water. The materials used were ground brimstone, and lime with a guaranteed analysis of 90 per ct. to 95 per ct. of calcium oxide. The wash was cooked in a 90-gallon kettle by direct team, using the formula: Lime 60 lbs., sulphur 125 lbs. and water 50 gallons. After the completion of the cooking, the mixture consisted of about two-thirds clear liquid, and had not more than 3 quarts of thick, unsprayable sediment to each barrel of concentrate. The average density of five batches was 31° B. In no case did an excessive amount of sediment occur. Mixtures have been made which have kept satisfactorily in storage over a year. Five barrels of concentrated mixture were made in one day, which cost on an average of about $2.31 for the sulphur, 40 cents for lime, 15 cents for coal and 30 cents for labor per barrel. Mr. Henion experienced no difficulty in making a satisfactory solution, but in advising other fruitgrowers to make their own mixture, he lays much emphasis on the importance of breaking up the lumps of sulphur and lime at the start, in order to obtain solutions of reasonably high densities.

Results on blister-mite.— Spotting of apple leaves by this pest was completely prevented.

Codling moth.— By the use of arsenate of lead in the lime-sulphur solution the losses to apple crop by this insect were very small.

Apple scab.— In comparison with the checks, marked results in preventing this disease on fruit were very apparent on all trees sprayed with the lime-sulphur solution 1–40. The foliage of Greenings showed conspicuous spray injury by the treatment with 1–30, and only slight damages from applications of 1–40. The crop of this variety was one of the cleanest ever harvested, largely due to the absence of russeting, which has frequently attended the use of bordeaux mixture in the past. Baldwin apples russeted badly, but trees sprayed with bordeaux mixture were usu-

ally much more blemished in this respect. Preference is given to the lime-sulphur solution for summer spraying of apples.

EXPERIMENT NO. XI.

H. L. Bulkley, Brockport, used the home-made concentrate of a density of 32° B. for blister-mite at a strength of 1 to 10 or 11, and for summer spraying of apples about 1 to 35. The materials for the preparation of the mixture were ground brimstone, and lime with a guaranteed analysis of 95 per ct. calcium oxide and practically free from air-slaked material. The wash was cooked with direct steam. The formula of 60 lbs. lime, 125 lbs. sulphur and 50 gallons of water was used, which gave about 40 gallons of clear liquid and 10 gallons of dark liquid, one gallon of which consisted of coarse and unsprayable sediment. The average reading of the clear solution of four preparations was 32° B. The mixture was stored in tight barrels and was used at intervals during one month. Four barrels were made in eight hours at a cost per barrel of $2.76 for materials, and $1.50 for labor.

Results on blister-mite.— Spraying with the home-made concentrate entirely controlled the work of the blister-mite on apple trees.

Apple scab.— The crop was clean with the exception of the variety Snow, which showed a small amount of scab. There were some evidences of burning of the foliage, and considerable russeting of the fruit, which was more conspicuous on trees sprayed with bordeaux mixture than on those sprayed with lime-sulphur solution. The opinion, however, is expressed that none of the treatments were responsible for the russeting, as unsprayed trees in the immediate vicinity were more affected.

EXPERIMENT NO. XII.

M. E. Ross, Avon, and Samuel Fraser, Geneseo, made four batches of the home-made concentrate for the treatment of peaches for leaf curl. The spraying supplies were sulphur flour, and

lime with a guarantee of 95 per ct. calcium oxide. The boiling was done by direct steam. The formula that was first tested was lime 60 lbs., sulphur 100 lbs. and water 50 gallons, but owing to the abundance of sediment the amount of lime was reduced in the last boiling to fifty pounds. In one batch of fifty gallons about one-third of the mixture was clear solution, while the residue was a dark greenish material of the consistency of molasses which choked badly the nozzles and the pump. In each boiling the sediment was of such a character that it could not be used in the spraying outfit and was therefore rejected. The cost of fifty gallons of the clear solution testing 27.5° B. was about $5.35 for the supplies, not including the expense of fuel and labor. On the basis of these results preference is given to the commercial mixtures.

Results on leaf curl.— This disease was satisfactorily controlled by the home-made concentrate. The lime-sulphur solution will be used in the future for the summer spraying of apples.

EXPERIMENT NO. XIII.

John Q. Wells, Shortsville, used the concentrated mixture testing about 32° B. at the rate of one gallon diluted with eight gallons of water for scale, and one gallon diluted with eleven gallons of water for the blister-mite. The materials used were commercial sulphur flour and flowers of sulphur, and lime which was guaranteed to be 99 per ct. calcium oxide and free from air-slaked material. The wash was prepared in a kettle and the formula used was lime 55 lbs., sulphur 120 lbs., water 50 gals. About 70 to 75 per ct. of the wash was of a clear amber color; and the balance consisted of a blackish liquid. The average density of five cookings was 32.9° B. There was very little mud and less than a quart of unsprayable material to each cooking. Mr. Wells states further that he experienced no trouble in making a satisfactory concentrate, and that it is no more difficult to make a barrel of concentrated mixture than the wash by the usual formula. The average cost of materials to make one barrel of concentrated mixture was $2.60.

Results on scale and blister-mite.—Both pests were efficiently combated by spraying with the concentrated solution.

Apple scab.— The apple crop was very free from scab and there was no appreciable evidences of either burning of the foliage or russeting of the fruit by summer spraying.

Codling moth.— Only small percentages of the apples were damaged by the codling moth, and it is believed on the basis of one year's experience that arsenate of lead used in a lime-sulphur mixture has proven as efficient a treatment for this pest as the same poison in combination with bordeaux mixture. In the future the lime-sulphur sprays will be used instead of bordeaux mixture for the treatment of apples.

EXPERIMENT NO. XIV.

E. D. Palmer, Stanley, prepared the concentrated wash for use on trees infested with scale and blister-mite. The diluted spray was applied at a strength of 4° to 4½° B. just before leaves appeared. The grades of materials used to make the mixture were sulphur flour and lime with a guarantee of 95 per ct. calcium oxide. The latter was clean lump lime and free from air-slaked material. The mixture was cooked by direct steam, the formula, lime 65 lbs., sulphur 125 lbs. and water 50 gallons, being employed. One hour's boiling increased the volume to about 54 gallons. The average density of the clear solution for 20 boilings was 26.5° B. At no time was the amount of sediment or mud excessive. Some barrels contained from 10 to 15 gallons of flocculent sediment and in others the insoluble material was as low as 6 gallons. Of unsprayable material consisting of coarse sediment there was about 3 quarts to a barrel of 50 gallons. The material was stored in barrels tightly corked for seven days without the formation of crystals. With the cooking plant as described, operated by one man, 5½ barrels of concentrated solution were prepared in a day at a cost per barrel of $2.74 for materials and 63 cents for labor and fuel. The containers used for storing the concentrate were oil and molasses barrels, purchased from local stores.

Results on blister-mite and scale.— The applications of the lime-sulphur solution efficiently controlled the blister-mite. The effects on the scale were not quite as satisfactory, for there was more or less breeding of the insect on some trees, resulting in a varying percentage of spotted fruit. Owing to the favorable reports from the use of sulphur sprays for foliage treatment, it is planned to employ the home-made concentrated solution for summer spraying of apples in place of bordeaux mixture.

EXPERIMENT NO. XV.

F. A. Salisbury, Phelps, used concentrate at 1 to 8 for blister-mite and leaf curl and 1 to 24 and 1 to 30 for apple scab and codling moth. The materials to make the mixture were sulphur flour, and lime guaranteed to contain 90 per ct. calcium oxide. The wash was prepared in iron kettles, the formula being lime 40 lbs., sulphur 80 lbs. and water to make 50 gallons. About 42 gallons of concentrated solution was obtained in each boiling, which gave an average density for 11 batches of 26.3° B. With two kettles about 300 gallons of concentrate were made in a day. The cost of materials averaged about $2.25 per barrel and labor about 40 cents. Kerosene-oil barrels purchased from a local dealer at $1.30 were used to contain the concentrated mixture. There was in none of the preparations an excessive amount of sediment, and as a rule there was not more than a quart of each lot that was unsprayable. In every batch there were about 15 gallons of very fine flocculent sediment which passed nicely through the nozzles. The mixture was stored for three weeks in barrels tightly corked and some of the material was also left in open barrels without a covering of oil during this time. Even with the exposed mixtures no crystals formed with the exception of a slight scum on the surface of the liquid, which was not considered important. On the basis of this year's experience it is more economical to make one's own concentrate than to buy commercial preparations.

Results on blister-mite.— This pest was completely held in check.

Codling moth.— Arsenate of lead in the lime-sulphur solution gave very satisfactory results in protecting the apple crop from losses by this insect.

Apple scab.— The fruit was the cleanest produced in many years. The spraying with lime-sulphur solution caused little or no injuries to the foliage and very little russeting of the fruit. The lime-sulphur solution is preferred to bordeaux mixture for the summer treatment of apples.

Leaf curl.— Early spraying gave almost complete protection to peach trees from this disease.

EXPERIMENT NO. XVI.

Arthur E. Bell, Milton, used the home-made concentrated mixture to combat the San José scale and the red spider. For the treatment of trees during the dormant season a gallon of concentrate of a density of 32° B. was diluted with eight gallons of water, and for the summer spraying of apples, pears and raspberries dilutions varying from 1 to 30 to 1 to 35 were employed. The mixture was made according to the formula, lime 55 lbs. and sulphur 125 lbs., and the boiling was done with steam coils. The average density of the preparations was 32° B. The concentrate was stored in barrels for about three weeks without any evidences of crystallization. The cost of the mixture was $2.78 for materials and $1 for labor, fuel, etc., per barrel. Mr. Bell states that the preparation of the concentrated wash has distinct advantages over the usual way of preparing this spray, which are the absence of coarse, clogging sediment, and its storable qualities, thus permitting preparations to be made when help is available.

Results on scale.— Young trees and currants badly infested with scale were especially selected as a test of the efficiency of the concentrate for this pest, and on all of these plants the scale was kept well under control.

Codling moth.— The results from spraying with lime-sulphur wash containing arsenate of lead on this pest were disappointing, for a great many apples were "wormy."

Red spider.— This pest was efficiently combated by summer spraying with the solution. Raspberry leaves that had been injured by red spider showed considerable spray injury.

Apple scab.—Apple scab was not noticeable on trees sprayed with the lime-sulphur solution, and there were no evidences of burning of the foliage. The lime-sulphur solution will be used in place of bordeaux mixture for summer spraying.

EXPERIMENT NO. XVII.

J. A. Hepworth, Marlboro, prepared the concentrated solution for the special purpose of spraying for the San José scale. The materials used were commercial sulphur flour and lime testing 97.6 per ct. calcium oxide. Lime, 60 lbs., and sulphur, 125 lbs., were used and the wash was cooked by direct steam in quantities of 100 gallons at one boiling. About three-fourths of the mixture was clear liquid, with a density of 28° to 30° B.; while the remainder was a thin, dark liquid, all of which was sprayable. There was about one-half gallon of unsprayable material to each barrel. Very little sediment occurred when the sulphur was made into a paste before mixing with the lime and when the mixture was well stirred during the period of cooking. Some of the concentrated mixture was stored in tight barrels all winter without the formation of crystals. With sulphur at $1.80 per cwt. and lime at $1.25 per barrel, the average cost of supplies to make a barrel of concentrate was $2.90. Labor, fuel and repairs amounted to about 25 cents per barrel. No difficulties were encountered in making the concentrate, and this method of preparing one's supply of lime-sulphur mixture is preferred to that usually practiced.

Results on scale.— Applications of the concentrated mixture almost completely checked the breeding of the scale and thus protected the new growth and fruit in a very satisfactory manner from this pest.

Apple scab.— Some summer spraying was done with very dilute preparations to control the apple scab, but the crop was so

small that there was no opportunity to ascertain the value of this spraying for this disease. However, there was no burning of the foliage or russeting of the fruit. On the basis of the results of these tests, the home-made concentrate will be used hereafter in place of bordeaux mixture for summer spraying.

SUMMARY OF VOLUNTEER EXPERIMENTS OF 1910.

The formula, quality of preparations and cost of materials to make each of these home-made concentrates are shown in the following table:

TABLE II.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN MAKING CONCENTRATED LIME-SULPHUR SOLUTION.

No.	Locality	NAME	Formula: Lime	Formula: Sulphur	Formula: Water	Density of clear solution	Volume of clear solution*	Cost per barrel: Material	Cost per barrel: Labor	Kind of cooking outfit
						Degs. B.	*Per ct.*			
1	Youngstown..	S. S. Hopkins................	65	125	50	28°	85	$2 55	$0 33	Direct steam
2	Lockport.....	Asa Baldwin................	50	100	58	22	......	2 65	50	Steam
			65	125	52	26	......	3 50	50	Kettle
3	" ...	A. H. Ernest................	50	100	50	31	90	2 30	30	Direct steam
4	Medina......	F. W. Paine	60	110	50	26.5 to 29.5	80	2 40	50	Kettle
5	"	A. J. Skinner................	65	100	65	29 to 32	75	2 20	50	Kettle
6	Carlton......	G. D. Simpson................	50	100	50	28	65	2 50	30	Kettle
			57	115	50	30.7				
	"	"	60	120	50	30	......	2 50	30	Kettle
			60	125	50	29				
7	Albion.......	Geo. B. La Mont..............	37	75	50	26.7	80	2 25	1 50	Kettle
8	"	B. L. Perkins................	50	100	50	29.6	......	2 18	50	Kettle
9	"	L. R. Rogers................	50	100	50	30	......	2 13	50	Kettle
10	Brockport....	B. H. Henion................	60	125	50	31	65	2 71	45	Direct steam
11	"	H. L. Bulkley................	60	125	50	32	80	2 76	1 50	Direct steam
12	Geneseo.....	M. E. Ross and Samuel Fraser..	60	100	50	27.5	33	2.10	.....	Direct steam
			50	100	50					
13	Shortsville...	John Q. Wells................	55	120	50	32.9	70–75	2 60	.....	Kettle
14	Stanley......	E. D. Palmer................	65	125	50	26.5	70–80	2 74	63	Direct steam
15	Phelps.......	F. A. Salisbury..............	40	80	42	26.3	60	2 25	40	Kettle
16	Milton.......	Arthur E. Bell..............	60	125	50	32	90	2 78	1 00	Steam coil
17	Marlboro.....	J. A. Hepworth..............	60	125	50	28 to 30	75	2 75	20	Direct steam

* These figures were based on samples that were allowed to settle in glass jars. The actual amount of sediment by weight was not determined. The analyses given in Table I show the actual weight of sediment in mixtures containing different volumes of it in suspension. While the volume of sediment in suspension appears large, the actual amount of dried material is usually only a small percentage of the total quantity of a mixture that is properly prepared.

RESULTS OF HOME-MADE CONCENTRATE ON BLISTER-MITE AND SCALE.

One of the principal objects of the volunteer experiments was to determine if fruitgrowers could efficiently combat the blister-

mite and San José scale by home-made concentrated mixtures. There are eleven experiments on blister-mite, and of these there are ten reports of satisfactory results in protecting apple foliage from this pest. The single failure (see Experiment 9) was attributed to lateness of application and not to any deficiency in the concentrate.

In spraying for the scale there were seven experiments, five of which were successful and two were partial failures. The disappointing results occurred in old apple orchards. The failure to control the scale entirely under such circumstances is not unusual with other kinds of spraying mixtures or with other forms of sulphur sprays. These experiences call attention to the necessity of thorough spraying and of the importance of using mixtures at effective strengths to obtain uniformly satisfactory results on this pest. The accounts of the spraying operations indicate that fruitgrowers appreciated the significance of the variations in their mixtures and were able, by the use of an hydrometer, to obtain diluted preparations of required density.

RESULTS OF HOME-MADE CONCENTRATE ON DISEASES.

In directing the volunteer experiments it was not intended to consider the fungicidal properties of the home-made concentrate, but as mention has been made in several instances of the effectiveness of the treatment for various diseases a word of explanation is desirable. Owing to the nature of the spraying operations, the results considered by themselves are in most cases not conclusive. The chief value of the reports is that they represent the opinions of the fruitgrowers themselves, who have estimated the benefits derived from their spraying by the general conditions of the crop or of the trees. In all instances spraying seems to have afforded efficient protection against leaf curl. The absence of scab and the clean character of the apples from trees sprayed with the home-made concentrate are in accord with the general experience of fruitgrowers who sprayed with the lime-sulphur wash this year.

INJURIES TO FOLIAGE AND FRUIT BY HOME-MADE CONCENTRATE.

Injuries by summer spraying with the lime-sulphur wash have been noted in a number of experiments. These have been stated to occur on the foliage and the fruit, and in the reports of the co-operating orchardists have been popularly characterized as burning of the leaves and russeting of apples.

BURNING OF LEAVES.

Injury to the leaves was a common attendant, this spring, of spraying with lime-sulphur mixtures and was perhaps more generally observed following the application just after blossoming than at any time during the spraying season. Trees that were affected had a varying percentage of the foliage spotted with brown areas of irregular sizes and shapes, which were especially prominent on the terminal growth, sides of unfolding leaves and leaves with upturned edges. In a few instances spraying at this time was accompanied with more or less defoliation. In general, the ill effects of the treatment on apple leaves were not of great consequence or of a lasting nature. The weather subsequent to the spraying was, because of frequent rains, very favorable to rapid growth, and injuries which at first excited more or less apprehension were soon obscured by the new foliage. The condition of orchards sprayed with the sulphur solutions was generally very satisfactory during the remainder of the season. Because of the extent of the new growth and the comparative freedom of the trees from insects, diseases and spraying injuries of the fruit, the burning of the leaves occurring early in the season is usually regarded as an incidental result, to which much importance should not be attached in view of the superior quality of the apple crop and the excellent condition of the foliage in late summer. Pears were generally more susceptible than apples to injuries of foliage by the lime-sulphur solution.

Injuries of a more serious nature than those described were of comparatively rare occurrence. Such injury has been noted once, in Experiment No. 5, in which the fourth spraying caused con-

siderable defoliation of the trees and dropping of apples. These results are perplexing, as this orchard is one of the most carefully managed plantings in the series of these experiments and had been thoroughly treated according to an approved spraying schedule. The circumstances of the treatment indicate that the injury was rather of an unusual nature. It is possible that the spraying mixture was too strong or was used too freely or that this experience is one of the rather rare instances of cumulative injuries from successive treatments as described by Scott* or of arsenical burning from the use of arsenate of lead in lime-sulphur sprays as recently mentioned by Wallace.†

RUSSETING OF APPLES.

One of the significant results of these experiments has been the comparative freedom of the apples from russeting. The absence of such blemishes on fruit from trees sprayed with the lime-sulphur wash has been the more conspicuous since there has been much complaint this season of severe russeting of apples by other spraying mixtures. The responses of co-operating orchardists with reference to the occurrence of russeting on trees sprayed with the lime-sulphur mixture have generally been "no russeting," "slight russeting," "no appreciable russeting" or "much less russeting than with bordeaux mixture." The fruit has, as a rule, been highly colored, with little or no russet blotches, such as had frequently attended spraying with bordeaux mixture, to detract from the waxy finish of the apple. Of the seventeen experiments only two have reported severe russeting of fruit, which was computed as less serious in extent than that occurring with bordeaux mixture.

ANOMALIES OF OCCURRENCE.

As has been the experience with bordeaux mixture, various anomalies have occurred in this summer's spraying with the lime-sulphur wash. Applications which have proven safe in most or-

* Lime-sulphur Preparations for Apple Diseases, U. S. Dept. Agr. B. P. I. Circular No. 54, p. 12.
† Cornell Bul. 288.

chards have caused more or less damage in some plantings. Injuries have occurred in some localities while in other parts of the State no unsatisfactory results have been noticed. Portions of a tree or a few trees may show burning while the remainder of the orchard may be unharmed. A variety such as Greening may have fruit immune to russeting and yet sustain injuries to foliage. Some varieties are more susceptible to injuries than others. Burning of leaves has attended the first spraying after blossoms dropped and in others has not occurred till later sprayings. Applications from the same tankful of mixture have caused injuries in one orchard and not in another. Trees have been drenched with strong mixtures without harmful results while more dilute preparations in moderate amounts have caused burning. The reasons given by orchardists for these contradictory results are "rapid growth of fruit and foliage," "leaves young and tender," "too much rain," "cold weather and rain," "cloudy conditions," "lack of sunshine," "prolonged cloudy weather," "sunshine following showers," "excessive use of spraying mixtures" "uneven distribution of the spray by worn-out nozzles" and "spraying while dew is on foliage."

It has not been possible to account for all the differences in the results by spraying. These seeming anomalies suggest that the occurrence of injuries were not due to a single factor but to several contributing factors, each of relatively greater or less importance according to the conditions of the orchard. Very tender foliage[1] of apples is susceptible to burning by the lime-sulphur solution and slight injuries are apparently unavoidable. The degree of tenderness of the new growth of the tree and its susceptibility to the spraying mixture appears also to vary with weather conditions. Cordley suggests[2] that "abundant sunshine and mild

[1] During 1910 pears generally seemed to be more susceptible to injuries of foliage than apples. Grapes were less resistant than pears. Mr. F. Z. Hartzell, in charge of investigations on grape insects, states that the foliage of Moore Early was badly burned at 1–60, and of Niagara and Concord at strengths of 1–75 to 1–100, while Delawares were uninjured at dilutions not stronger than 1–65. Damage to foliage was more serious on vines attacked by destructive numbers of leaf hoppers. Similar results have been noticed on raspberry foliage injured by red spider (*Bryobia pratensis* Gar.). During 1909 and 1910 J. P. Stewart (Letter December 7, 1910) also noticed that varieties differed in degree of susceptibility and that there was an apparent seasonal difference in varietal resistance. Apples this past year showed more injuries to foliage at dilutions of 1–28 than during 1909 when sprayed with 1–14.

[2] A. B. Cordley, *Better Fruit*, 8: 34.

temperature produces a vigorous, hardy, spray-resisting growth of foliage, * * * while excessive rainfall, cloudy weather and low temperature produces a growth less vigorous, less hardy, more edematous and more susceptible to spray injury." During cloudy and humid weather evaporation is also less rapid and the foliage is consequently longer exposed to drops of the spray of injurious densities.

On the basis of his investigations in New York, Wallace[1] considers that the conditions of foliage with respect to injuries by fungi and insects, general vigor of trees and the nature of spraying, whether excessive or moderate, have also an important bearing on the occurrence of injuries. Stewart[2] in summarizing the season's results in Pennsylvania states that "some burning of foliage, and occasionally of fruit, is likely to occur as a result of spraying with the lime-sulphur solution. Ordinarily the injury is negligible in extent, and as the trees recover rapidly the slight sacrifice in leaves may usually be overlooked. The occasional occurrence of decided injury, however, is of great importance and cannot be traced to a single cause. The rupturing of the epidermis by insects, fungi and frosts is one of the main factors. The epidermises may also be broken by the spray itself as a result of abundant application, which collects into drops and evaporates to injurious densities. (Penn. Sta. Ann. Rept. 1908–9, pp. 286–289.) With the breaking of the epidermis opportunity is afforded for severe injury by later treatments. This latter consideration would seem to account for the occurrence of severe injuries resulting from the third or fourth application of lime-sulphur solution in a proper spraying schedule, which should eliminate the work of insects and fungi as the determining factors; and for the destructive effects of an application of lime-sulphur solution following treatment with bordeaux mixture, which may also rupture the epidermis of relatively young leaves." 'Lime-sulphur[3] solution is probably more severe upon broken epidermises than bordeaux mixture, though less harmful on sound ones."

[1] Errett Wallace, Cornell Bul. 288.
[2] J. P. Stewart, letter December 7, 1910.
[3] J. P. Stewart, *Rural New Yorker*, 69; 1096. 1910.

DIRECTIONS FOR MAKING AND STORING THE HOME-MADE CONCENTRATED LIME-SULPHUR WASH.

FORMULA.*

Lump lime	Pure CaO	36 lbs
	or	
	95 per ct. CaO	38 lbs.
	or	
	90 per ct. CaO	40 lbs.
Sulphur		80 lbs.
Water		50 gals.

MATERIAL.

The forms of sulphur which are adapted for concentrated mixtures are flowers of sulphur, and light and heavy sulphur flour. There is also a cheaper grade on the market which is sold as "ground brimstone" or "commercial sulphur flour 99½ per ct." for about $1.75 per cwt. This when finely ground and bolted has given satisfaction. Sulphur can be obtained from the State Fruit Growers' Association, wholesale druggists and dealers in spraying supplies.

The lime should be fresh lump lime, free from dust and grit. It should test not less than 90 per ct. calcium oxide and should contain not more than five per ct. of magnesium oxide. Fruit-growers may sometimes purchase a satisfactory local lime, but before undertaking extensive operations one should assure himself that the quality is desirable. The Station has a list of dealers who will guarantee their lime; and this will be sent on application.

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* The attention of fruit growers is called to the new formula which has been devised by the Chemical Department of this Station, as described in full in Bulletin 329. The investigations of the lime-sulphur mixture have shown that by the proposed formula there is a more economical use of the spraying materials, which effects a considerable reduction in the cost of making the concentrate.

The formulæ which have been largely used in the experiments discussed in this bulletin are,—

1.	Lump lime	60 lbs.
	Sulphur	120 lbs.
	Water	50 gals.
2.	Lump lime	50 lbs.
	Sulphur	100 lbs.
	Water	50 gals.

COOKING THE WASH.

Heat about ten gallons of water in the cooking vessel and use it to slake the lime. To avoid losses of materials by spilling over, the lime should be added in small quantities at a time. As the slaking commences empty in the sulphur, and keep the mixture well stirred to break the lumps of sulphur and lime. When the entire amount of lime has been slaked, add the full amount of water. A sufficient quantity should also be added to provide for shrinkage by the cooking so that at the completion of the boiling there will be approximately fifty gallons of mixture. With kettles, an allowance of ten or more gallons may be required, while an outfit using direct steam will usually not need additional water. A few boilings should indicate the quantities of water needed to make approximately the amount of concentrate given in the formula. In using barrels or kettles of fifty gallons capacity, it is advisable to make one-half of the mixture provided by the formula to avoid losses by the boiling over of the materials. Boil the wash vigorously for one hour, in which time the sulphur should be completely dissolved.

A measuring stick, gauged to the capacity of each cooking vessel, will enable the fruitgrower to judge fairly accurately the volume of his spraying material.

STORAGE OF LIME-SULPHUR SOLUTIONS.

If the concentrate is not for immediate use, it should be stored in tight containers. After boiling is completed, strain the mixture into a barrel which should be corked. A sample of the clear solution should be tested by the hydrometer, and the reading marked on the container to indicate the required dilution for future use. The coarse particles of sulphur in the residue may be cooked in later boilings. It is not advisable to attempt to separate the clear liquid from the sediment because of the time required by the operation and the loss of efficient liquids.

Lime-sulphur solutions may safely be stored if they are not subjected to very low temperatures. In general, one should avoid prolonged storage and prepare the mixtures just preceding or at the time of the spraying operations, when danger of freezing is

avoided. According to Stewart * a solution of 32.1 Beaumé (1.28 Sp. G.) does not freeze above 5° F. and shows no deterioration by freezing. Mixtures of lesser density will freeze at higher temperatures. Preparations that are to be used within a few days may be kept, if desired, in open barrels. In this case, transfer the hot concentrate to the proper container, and cover the surface of the liquid with a thin film of mineral oil.

DILUTIONS FOR DORMANT AND SUMMER SPRAYING.

For strong mixtures for the scale, the diluted preparation should test about 4.5° B.; for blister-mite about 3.5° B.; and for summer spraying of apples about 1° B.† Using these figures as bases, the table below has been calculated, which shows the dilution required for a wide range of densities.

TABLE III.— DILUTIONS FOR DORMANT AND SUMMER SPRAYING WITH LIME-SULPHUR MIXTURES.‡

Reading on hydrometer.	Amount of dilution. Number of gallons of water to one gallon of lime-sulphur solution.		
Degrees Beaumé.	For San José scale.	For blister-mite.	For summer spraying of apples.
36	9	12½	45
35	8¾	12	43¼
34	8¼	11½	41½
33	8	11	40
32	7½	10½	37¾
31	7¼	10	36¼
30	6¾	9½	34¾
29	6½	9	32¼
28	6	8½	31
27	5¾	8	29½
26	5¼	7½	27¾
25	5	7	26
24	4½	6½	24¼
23	4¼	6	22¾
22	3¾	5½	21¼
21	3½	5	19¾
20	3¼	4¾	18¼
19	3	4¼	17
18	2¾	4	16
17	2½	3¾	15
16	2¼	3¼	14
15	2	3	12¾

* Penn. Sta. Bul. 92.
† This density of the diluted mixture is based on the recommendation of Wallace (Cornell Bul. 289) who advises for summer spraying of apples one gallon of concentrate testing about 32 to 33° B. diluted with forty gallons of water.
‡ These dilutions are based on the calculations in Table XI, Bul. 329

THE HYDROMETER AND ITS USES.

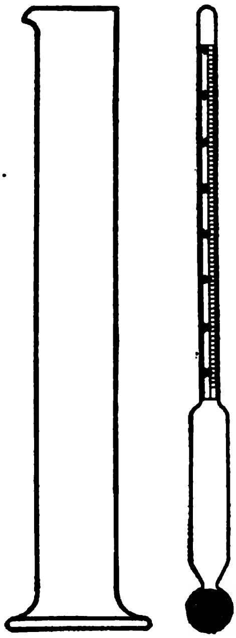

Fig. 1.

The lime-sulphur solution made by the fruitgrowers is likely to vary in strength or degree of density of the clear liquid. It is important, especially in spraying for the scale, that the solution shall be diluted according to its degree of concentration in order that the mixtures may always be of a definite strength. Knowing the density of the clear solution, it is a simple matter to obtain diluted mixtures that are approximately uniform in their insecticidal properties. The hydrometer is used for this purpose. It is a glass instrument, consisting of a weighted bulb with a long stem, which determines the weight or density of liquids. Its general appearance is indicated in Fig. 1, which also shows a convenient glass vessel for holding the lime-sulphur solution. On the stem of the instrument there is a graduated scale, which should be read at the general surface of the liquid in which it is supported. Hydrometers in common use are of two kinds,— the Beaumé and the Specific Gravity, which differ in the standards of measurements on which the graduated scales are based. There are instruments which have both measurements. Readings on the former are given in numerals expressed as degrees, while those on the latter are made in decimals. Instruments with a range of 0 to 38 degrees Beaumé or 1.000 to 1.349 specific gravity are recommended. Hydrometers do not detect impurities in lime-sulphur solutions; these can be determined only by chemical analysis. Hydrometers of the above specifications can be purchased from the Bausch and Lomb Optical Co., Rochester, N. Y., and undoubtedly from wholesale dealers in druggists' supplies.

THE APPLE AND PEAR MEMBRACIDS.*

H. E. HODGKISS.

SUMMARY.

In some investigations of common fruit pests, eggs of various species of Membracids were commonly found in buds and young wood of apples and pears. The laying of eggs in the buds is apparently an unrecognized habit for these insects. The frequent occurrence of eggs led to breeding experiments to ascertain the identity of the species.

Ceresa taurina Fitch and ***Ceresa borealis*** Fairm. oviposit in the buds. ***Ceresa bubalus*** Fabr. and ***Stictocephala inermis*** Fabr. lay their eggs in the bark of the young wood. The species ovipositing in bark cause characteristic scars.

In rearing a large number of individuals five distinct stages were completed before the appearance of the adult. The nymphs of the species mentioned may be recognized in their different stages principally by the structure of the appendages, the character of the spinosity of the body and the coloration.

The species breeding on apples and pears depend on succulent weeds and plants for the sustenance of the nymphs. The range of host plants is quite extensive.

Egg parasites have been quite common during the past three years. Two species have been bred which are ***Polynema striaticorne*** Gir. and ***Ottys ceresarum*** Ashm. These attack all species.

C. bubalus is the more destructive species to apple and pear wood. ***S. inermis*** does not cause injuries of an important nature. The insertion of eggs between the bud scales by ***C. taurina*** and ***C. borealis*** appears to have no detrimental influence on the development of the buds.

Clean cultivation to prevent the growth of the hosts of the nymphs is the most practicable and efficient remedy for the prevention of injury by the tree-hoppers.

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*A reprint of Technical Bulletin No. 17.

INTRODUCTION.

Some investigations which have been conducted on several apple and pear insects during the past few years have shown the presence of insects on these fruits which are responsible for eggs in wounds in the bark and in the buds. An examination of the eggs indicated that they had been laid by Membracids. A reference to literature gave no clue to the species other than the buffalo tree-hopper, *Ceresa bubalus* Fabr., and a closely related species, *Ceresa taurina* Fitch. The apparent impossibility of locating from literature the form responsible for oviposition in buds has prompted an extended series of breeding experiments, the results of which form the basis of this bulletin.

The writer is greatly indebted to Mr. E. P. Van Duzee for the specific determination of the insects and for valuable suggestions and criticisms of the manuscript. Mr. A. A. Girault very kindly named the parasites and gave much valuable data on the species. Dr. H. Fernald allowed the use of his library and the card catalogue of entomological literature at the Massachusetts Agricultural College, for which courtesy I am greatly indebted. The investigation was made under the supervision of Mr. P. J. Parrott, to whom I am especially obliged for constant advice and help.

THE MEMBRACIDÆ.

HISTORICAL.

The work of Stâl[1] has placed the family on a firm systematic basis. The synopsis of the genera by Dr. Goding and his later catalogue[23] are valuable for the species recognized at that period. A large number of our native forms were described by Say,[2] Fitch,[3] and Emmons;[4] the publication of the latter being chiefly valuable for the illustrations. The recent study of Van Duzee[24]

1 Bid. Hemip. Syst. 24:491. 1867. Hem. Fabr. 2:18. 1869.
23 Ill. St. Lab. Nat. Hist. 3. 1894.
2 Ent. N. A. (Le Conte Ed.) 1:198; 2:376. 1891.
3 Cat. Hom. N. Y. 1851. Rpt. Ins. N. Y. 3. 1856.
4 Agr. N. Y. 5:152. 1854.
24 Bul. Buff. Soc. Nat. Sci. 9:29–119. 1908.

is the most serviceable and best guide to the systematic knowledge of the family.

Contributions to the knowledge of some of the species of economic importance have been made by Fitch,[5] Riley,[6] Marlatt,[7] and Jack.[8] There are many references in literature to *bubalus*, which are largely compiled from the writings of Riley and Marlatt.

FOOD PLANTS.

The food plants of the Membracidæ have been listed by Dr. Goding.[23] Other writers have named the host plants of different species without distinguishing between the food plant and the host in which the eggs are laid.

From our observations we may conclude that in general trees and shrubs serve chiefly for the deposition of eggs and as food for the adults. The more succulent foods are necessary to sustain the younger stages. Among these should be mentioned the wild parsnip (*Pastinaca sativa* L.), great burdock (*Arctium lappa* L.), daisy fleabane (*Erigeron annuus* Pers.), wild carrot (*Daucus carota* L.), Canada thistle (*Circium arvense* (L.) Scop.), bull thistle (*Cirsium lanceolatum* (L.) Hill), moth mullen (*Verbascum blattaria* L.), New England aster (*Aster novæ-angliæ* L.) and other Aster spp. Other succulent plants which have been mentioned are potato, tomato, Japan lily, ragweed (*Ambrosia* sp.), and various other succulent cultivated plants.

GENERAL DESCRIPTION OF LIFE STAGES OF MEMBRACIDS.

Adult stage.— The Membracidæ are curious insects, the peculiar shapes assumed by the pronotum creating popular as well as scientific interest. In general outline the tree-hoppers have the appearance of angular seeds or nuts. The pronotum often forms a high, arched crest above the body; it may be elevated,

[5] Rpt. Ins. N. Y. 12:889. 1867.
[6] Rpt. Ins. Mo. 5:121. 1872.
[7] Kans. Acad. Sci. 10:84. 1886. *Ins. Life,* 7:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. 23, 2d Ser. 1897.
[8] Rpt. Ent. Soc. Ont. 17:18. 1887.
[23] Ill. St. Lab. Nat. Hist. 3. 1894.

giving rise to one or more humps, may bear spine-like processes over the head, and may be smooth, pitted or extended horizontally. The color is commonly green or brown, spotted or banded. The greatest diversity of color and form is found among the luxurious vegetation of the South American tropics. In our cooler climate the less brilliant and inconspicuous species are common.

Egg stage.— The egg is tooth-shaped or wedge-shaped. The chorion is translucent when the egg is first deposited, but may become dirty white or purplish in color before the insect hatches. The size may vary with the species but in general it averages about 1.5 mm. in length.

Nymphal stages.— The observations of Riley during the year 1872 indicated that *C. bubalus* Fabr. (*taurina* Fitch)[9] transformed four times before the adult appeared. In our studies on *bubalus, taurina, borealis,* and *Stictocephala inermis* each species produced five molted skins before maturity. The general character of the several instars are as follows:

FIRST INSTAR: The first stage of the nymph is quite distinct from the later instars. It may be recognized by the structure of the double row of prominent tuberosities along the dorsal ridge. These are composed of a stout basal portion narrowing at the apex to a slender hair, with one shorter hair arising from a fork near the middle of the protuberance.

SECOND INSTAR: This may be recognized by the dorsal tuberosities becoming complexly forked, rather widely separated and small in size.

THIRD INSTAR: The third stage may be recognized by the increased branching of the dorsal processes which at this time curve noticeably; the tuberosities on the thorax incline somewhat forward and the abdominal processes more strongly backward. The wing pads begin to show during this instar.

FOURTH INSTAR: The dorsal processes are more strongly branched and curved. The wing pads in this stage overlap the second abdominal segment. The chief change is the presence of a

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[9] Rpt. Ins. Mo. 5:121. 1872.

distinct segmentation in the thorax. The pronotum is strongly produced above and in the dorsal median is extended caudad in form of a short, horn-like process which nearly reaches the mesothoracic tuberosities.

Fifth instar: The dorsal processes at this time bend more strongly forward and caudad, or may be much reduced in size. The pronotum is more distinctly produced backward in a sterni form process which is rather long. The prothorax is more or less flat in front. The abdominal tuberosities are often very much reduced in size.

STUDIES ON THE LIFE HISTORY AND HABITS OF MEMBRACIDS.

METHODS OF STUDY.

The observations on the life cycle of the tree-hoppers were made in the laboratory. The twigs and buds containing eggs were placed in jars of moist sand beneath bell-jars, and on hatching, the nymphs were transferred to plants in breeding cages. Young apple and pear trees in pots were principally used for host plants. Succulent growth was forced from the trees, which seemed to meet the needs of the hoppers in the first nymphal stages. When the nymphs became restless and refused to remain on the trees they were transferred to tender plants, principally the thistle.

Eggs were obtained by confining individual adults on young apple and pear wood.

FIRST APPEARANCE OF ADULT AND LENGTH OF LIFE.

The imago appears about the middle of July. In 1908 the first individuals of *C. bubalus* were seen on July 2, but the insects were not numerous until July 20. During the season of 1910 a large number of the adults of *S. inermis* were collected on July 12, but *C. bubalus* and *C. borealis* at this time were rather rare. *C. taurina* was not obtained until July 20, at which time all species were abundant. Mr. J. G. Jack records

the presence of adults of *C. bubalus* in an orchard on July 16, which became numerous a few days later. Our breeding records show that one individual became adult on June 30, and lived after oviposition had ceased until Sept. 1 when it was killed. Jack records *C. bubalus* on Oct. 26,[6] and Marlatt reports the presence of this insect Oct. 24.[7] In general, adults of the species mentioned may be found over a period beginning about the middle of July and ending with the first heavy frost.

FEEDING OF ADULTS.

The adults, especially females, undoubtedly feed on trees. The evidence in favor of this habit is based upon adults kept in breeding cages which lived only two or three days upon aster and thistle, while nymphs in every instance thrived on these plants. Mature individuals confined on two-year-old apple and pear wood lived through the normal period. Soon after maturity and some time before oviposition commenced large number of males were collected which were apparently subsisting on two and three-year-old wood of apple and pear.

PERIOD BETWEEN MATURITY AND OVIPOSITION.

Specimens of *S. inermis,* which transformed to adults in the laboratory June 30, commenced to lay eggs on July 20. Under natural conditions the earliest oviposition was noticed on August 1, but the egg scars were not abundant until a few days later. Jack records his first observations of egg-slits as August 12.[8] During 1908 no eggs of *C. borealis* or *C. taurina* were found until August 24.

RATE OF DEPOSITION AND NUMBER OF EGGS.

Adults of *inermis* reared in the laboratory usually made two egg scars in one evening. Occasionally four slits in the bark for the reception of the eggs were cut in one day. One individual

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[6] Rpt. Ent. Soc. Ont. 17:18. 1887.

[7] Kans. Acad. Sci. 10:84. 1886. *Ins. Life,* 7:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. 23, 2d Ser. 1897.

made 59 scars during July and August in which 252 eggs were deposited. Another female inserted 212 eggs in 39 wounds during the same period.

DURATION OF OVIPOSITION.

Specimens which were laying eggs (in the laboratory), on July 20, 1909, ceased oviposition during the period between Sept. 11 and 27. In orchards about Geneva scars were most numerous on Aug. 15, 1909. At Syracuse, on Aug. 20, 1909, the slits caused by *C. bubalus* were rarely observed in orchards; but on Sept. 20 many of the trees were very severely injured by the work of this insect. During the seasons of 1909 and 1910 at Geneva, deposition of eggs had ceased by Aug. 24 and adults were not found in the trees or taken at the net after Sept. 26. During his studies in Kansas, Marlatt[7] observed adults as late as Oct. 24, at which time egg laying had evidently ceased. Jack reported that the oviposition of *bubalus* continued between Aug. 12 and Oct. 26, 1886.[8]

DESTRUCTIVENESS OF INSECTS.

The injurious species are those which slit the bark during the process of oviposition. The destructive work often occurs on young trees along the roadside, or along the boundaries of fields which receive little or no cultivation. Trees which are attacked by these insects are often stunted in growth and the branches are weakened by continual scarification. These injuries are often aggravated by destructive fungi and insects which find lodgment in the wounds.

PLACE SELECTED FOR THE EGGS.

The adult females when ready to deposit eggs usually select the two or three-year-old wood, or the buds of its particular host trees. Marlatt observed that the buffalo tree-hopper did not con-

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[7] Kans. Acad. Sci. 10:84. 1886. *Ins. Life*, 7:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. 23, 2d Ser. 1897.

[8] Rpt. Ent. Soc. Ont. 17:18. 1887.

fine its work to such wood although showing a preference for it.[7] Certain species often choose weeds for this purpose. Unidentified Membracid eggs which had been deposited within the petiole of the leaf were collected on weeds during 1908. Mention of weeds being a receptacle for eggs of *bubalus* has been made by Marlatt.[7]

DURATION OF EGG STAGE.

Hatching takes place about April 20, according to the season, and nymphs of the first stages may be found in goodly numbers on apple and pear trees until May 24. Jack reports that eggs were hatching on June 6,[8] which is the latest date in our records for the appearance of young nymphs.

HATCHING OF THE EGGS.

As the embryo develops, a suture gradually appears in the apex of the chorion which permits the extrusion of an inner cap. The process takes place very slowly so that the head and thorax are usually freed simultaneously with the egg-cap. The abdomen is released by a swaying movement until the anal segment alone is attached. The insect then remains quiescent in a perpendicular position, often for a period of two minutes, after which spines and other appendages are released. These are seen one at a time, those on the head appearing first and later those on the thorax and abdomen. The legs gradually become extended, each pair separately; the metathoracic legs obtain freedom at the same time as the hairs and dorsal spines of the third abdominal segment. After the appendages and ornaments are released the creature remains erect for the space of one minute before dropping and separating itself from the shell. The entire process occupies a period varying from seven to nine minutes.

DURATION OF NYMPHAL STAGE.

The period elapsing between the nymphal stages of Membracids reared in the laboratory varied with the different instars,

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7 Kans. Acad. Sci. **10**:84. 1886. *Ins. Life*, **7**:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. **23**, 2d Ser. 1897.
8 Rpt. Ent. Soc. Ont. **17**:18. 1887.

and to some extent with the individuals. The number of days from hatching to maturity of 20 nymphs of *C. taurina* in the breeding cages was 47 days. The first and second instar averaged 8 and 7 days respectively; the third instar, 7 days; the fourth instar, 9 days; the fifth instar or pupal stage lasted 16 days. These records correspond very well with those of the nymphs growing under natural conditions, which averaged seven days to an instar.

During 1906 a considerable number of individuals were required to feed on succulent shoots of pear-tree foliage. The first instar lasted from 13 to 24 days; the second from 8 to 10 days; the third 12 to 13 days, and the fourth 13 days, after which the individuals died.

THE ECDYSIS.

The first indication of molting is an apparent drying of the integument. This may be seen for the most part about the more translucent parts of the body, especially in the lighter-colored nymphs such as those of *C. taurina*. When the actual ecdysis begins, the nymph becomes quiet and soon a split appears in that portion of the pronotum over the head, which continues gradually along the dorsal median of the thorax. By this time the head is partly released and the thorax is forced out, enlarging as it becomes detached. The legs remain encased until after the third abdominal segment is released. The remaining segments slowly appear, extending gradually as they become free. The operation from the splitting of the skin over the thorax until the body is extruded occupies seven minutes. Another minute is necessary for the body to become dry. The legs are not used during the operation and do not become ready for use until the skin is off. The old integument is not fastened to the leaf during molting and very often remains attached to the anus for some time after the body is released.

FEEDING AND GREGARIOUSNESS OF NYMPHS.

For a short time after hatching the nymphs remain on the foliage of apple and pear trees but soon they become rather

active and seek other hosts, either working their way down the trunk or dropping from the limbs of the tree to the ground. They immediately assemble on weeds, the juices of which seem necessary for their sustenance. In one instance a single nymph was found feeding on thistle in an oat field 40 feet from grass or weeds or the tree which probably contained the egg from which this insect hatched.

These insects have been said to be gregarious. In the nymphal stages this tendency is not seen in a marked degree. The existence of several young on one stalk appears to be accidental. Although the hoppers have been abundant near Geneva, only a single specimen is usually taken from one plant and the largest number ever captured was three. This tendency to solitary existence continues throughout the life of the nymph.

METHOD OF FEEDING AND INJURIES CAUSED BY NYMPHS.

The nymphs in the first stage usually move to the under side of a leaf or petiole, as if hiding from strong light. Later they appear to be less sensitive and may be found in various positions on the leaf. The nymphs while feeding usually have their heads directed downward.

No mention has been made by other writers of injuries to pear and apple foliage during the short period that the nymphs remain on the trees. Succulent shoots of pear when used in the laboratory for food were always girdled about the larger portion of the stem.

Such work is always present on the more succulent food plants, and of these the thistles are apt to show the effects of the girdling most severely.

CONTROL OF MEMBRACIDÆ.

EGG PARASITES.

Two species of parasitic hymenoptera have been bred from eggs of *C. bubalus.* Miss Murtfeldt has reported that an unde-

scribed species of Cosmocoma (Polynema)[11] had destroyed most of the eggs received by her from several localities in Missouri.[10] Marlatt suggests that egg parasites which were observed by Jack[8] were of this species, and also refers to a species described by Dr. Ashmead[12] which was bred from eggs of *C. bubalus*. The latter he found to be *Trichogramma* (*Ottys*) *ceresarum* Ashm.[13] The common form attacking eggs about Geneva is *Polynema striaticorne* Gir. Individuals of this species have been compared with the species taken by Miss Murtfeldt in Missouri and pronounced by Mr. Girault to be identical. These parasites are very abundant even in orchards most severely injured by tree-hoppers.

MEASURES FOR THE PREVENTION OF INJURIES.

Trees that have been much attacked by tree-hoppers should be stimulated to outgrow the injuries by careful pruning and cultivation. The use of insecticides against these insects is impracticable owing to the habits of both the larvæ and the adults. The feeding of the nymphs on succulent vegetation provides a remedy in clean culture. The destruction of weeds by cultivation during the months of May and June, for the purpose of removing all succulent vegetation on which the nymphs feed, will protect the young trees from attack by the adults.

THE APPLE AND PEAR TREE-HOPPERS.

SYSTEMATIC RELATIONSHIPS.

The tree-hoppers included in this investigation belong to the tribe *Cerasini* Goding of the sub-family *Smiliida* Stal. The species are distributed in two genera, *Ceresa* A. & S. and *Stictocephala* Stal, and may be determined by the accompanying table which is adapted from that of Van Duzee.

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11 Mr. Girault informs me that this species is *P. striaticorne* Gir.
10 Hort. Soc. Mo. Rpt. 32:50. 1889.
8 Rpt. Ent. Soc. Ont. 17:18. 1887.
12 *Ins. Life*, 7:13. 1894.
13 *Can. Ent.* 20:107. 1888.

SYNOPTICAL TABLE.

SUB-FAMILY **SMILIIDA** STAL.

Elytra free with clavus uncovered, its posterior margin touching the external margin of the pronotum. I. *Cerasini* Godg.

I. TRIBE **CERASINI** GODING.

Corium with two veins contiguous at base, sometimes united in one.

A. Pronotum armed with suprahumeral horns, sometimes reduced to mere tubercular angles. 1. *Ceresa* A. & S.

B. Pronotum without suprahumeral horns, the sides of the metopidium at most obtusely angled. 2. *Stictocephala* Stal.

Corium with two distinct veins at base, contiguous at most but for a short space at base where they are subobsolete.

(Genera not included in this table.)

1. GENUS **CERESA** A. & S.

Green, flavous or piceus species, not transversely banded.

Suprahumerals distinctly produced in horns, at times but short and triangular.

Clypeus short, at apex continuing the contour of the outer margin of the cheeks. Suprahumerals prominent, acute, produced horizontally, little if at all curved posteriorly; metopidium transversely flat.

Length 8–10 mm. *bubalus* Fabr.

Clypeus triangularly produced beyond the line of the cheeks. Metopidium flat or concave between the suprahumerals, sometimes a very little convex at the middle.

Length 8–10 mm; suprahumerals long, subterete, sloping upward and curved backward. *taurina* Fitch.

Smaller, 7–8 mm; suprahumerals shorter, triangular, abrupt, horizontal, a little curved backward. Pronotum, hairy; ultimate ventral segment of the female acutely emarginate; venter of the male concolorous; inhabits east of the Rocky Mts. *borealis* Fairm.

2. GENUS **STICTOCEPHALA** STAL.

Carinate sides of the metopidium meeting before the middle of the body.

Metopidium widened upward to the rounded suprahumerals. Loriae continuing the rounded contour of the cheek, the clypeus scarcely longer. Last ventral segment of female broadly sub-angularly excavated behind. *inermis* Fabr.

Carinate sides of the metopidium meeting at or behind the middle. (These species are not included in this bulletin.)

CERESA BUBALUS FABR.

HISTORICAL.

This species, commonly known as the buffalo tree-hopper, was described by Fabricius[25] in 1794. For many years no special effort seems to have been made to ascertain its life history and habits. In 1867 Fitch published an extended account of this species in which the eggs of the common tree cricket *Oecanthus* (*niveus*

[25] Ent. Syst. 5:14. 1794.

DeG.[14]) *nigricornis* Walk., were described as those of *Ceresa bubalus*[26]. Riley in 1873 criticised him for this oversight in a discussion on the eggs and early stages supposed to be those of *bubalus* but which were later mentioned as those of *Ceresa taurina*.[19] The most valuable studies which have since been published are by Jack in Canada,[8] and Marlatt in Kansas.[7] The studies of Marlatt are the more complete and with his later paper[7] on the same subject form the basis of much of the economic literature on this species.

TECHNICAL DESCRIPTIONS.

ADULT.

Pronotum considerably elevated; metopidium transversely flat; suprahumerals moderately prominent; short; acute, produced horizontally, seldom recurved; surface evenly punctate, with a strong median carina; anterior margin deeply sinuate, slightly recurved at the eyes; callosities plainly distinguished; posterior portion narrowed gently, margins strongly recurved; horn long, usually amber in color, black at tip, and extended beyond the anal tube. *Head* large, strongly produced above the level of the eyes at the middle; anterior margins of cheeks straight, not reaching the apex of the tylus; tylus large, reaching half way to base of head, at apex longer than cheeks and loriæ; anterior margins continuing the triangular outline of the head. Last *ventral segment* of female wide; rounded on either side of the obtuse median notch. The *plates* of the male broad, reaching the tip of the anal tube.

Color.— Green, usually flavous in preserved specimens. Prothorax more or less spotted with white in fresh specimens. Wings hyaline; testaceous at apical margins.

EGG.

Tooth-shaped; elongated; base rounded; lateral margins slightly curved, tapering gradually toward apex, more sharply curved near base; apex bluntly pointed. *Chorion*, vitreus; sculptured, *sculpture* showing as faint reticulations *Cap*, large; lateral margins strongly inflected and meeting at apex; sculpture coarse, papilliform, circular in cross-section. *Size:* Av. length 1.5 mm.; av. greatest width 0.38 mm.; av. width at cap. 0.28 mm.

NYMPH.

First instar: *Body* small; triangular in cross-section; long; narrow; widest at the head, narrowing gradually to anal tube. Prominent tuberosities are borne in pairs on both sides of the median of the several segments. *Head*, large; ventose, face and mouth parts directed downward and backward; eyes compound; bearing two stout hairs. Integument rough, with numerous microscopic hairs set on minute papillæ. Several regularly placed,

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14 This should be *Oecanthus nigricornis* Walk., as recent investigations have shown that *O. niveus* DeG. lays its eggs singly.

26 Rpt. Ins. N. Y. **12**:889. 1867.

19 *Proc. Ent. Soc. Wash.* **3**:88. 1892.

8 Rpt. Ent. Soc. Ont. **17**:18. 1887.

7 Kans. Acad. Sci. **10**:84. 1886. *Ins. Life,* **7**:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. **23**, 2d Ser. 1897.

long hairs and a number of shorter ones arise from the head and its appendages; the longer hairs originate from sizable nipple-shaped tubercles. On the vertex each side of the median and rather widely separated are the first pair of tuberosities, much swollen at the base, gradually contracting for about four-fifths of its length, and then abruptly compacting to form the base of a single long hair. Near its apex the tuberosity is surrounded by a number of regularly placed minute spines which give a ringed appearance to the projection.

The *prothorax* bears four tuberosities. The cephalad pair are shorter and thicker at the base than the preceding prominences and terminate in a single stout hair. The caudal tuberosities are slightly narrower at the point of attachment to the body and forked near the apex. The forward arm bears a single, short, stout hair, while on the other branch is a stouter and very much longer hair.

The *mesothorax* has a similar pair of forked tuberosities. The hair arising from the cephalad arm is longer and less stout than that on the prothorax. The terminal hair is of about the same size as the corresponding one on the preceding pair of prominences. Below and laterad of the lower branch is a single stout spine.

The *metathorax* bears one pair of tuberosities similar to those on the preceding segment except that it is less stout and has the caudo-lateral margin strongly incurved. The stout spine is placed caudo-lateral and is finer and longer than the corresponding spine on the mesothorax.

Abdomen.— The first abdominal segment bears two simple hairs in the place of tuberosities. The tuberosities on the other abdominal segments are more slender than the forked processes on the thorax and are inclined backward, slightly at first, continuing more strongly so until the sixth pair is considerably bent, with its apical hairs reaching to the tip of the anal tube.

The caudal tuberosities are short, stout and not branched, but bear a cephalo-basal spine and a sizable lateral spine somewhat higher than the basal spine. A ring of strong finely-pointed hairs extends around the anal tube.

Three parallel rows of long, stout hairs arise from tubercles close to the caudal margin of each segment. The legs are clothed with strong, spinous hairs. The venter is depressed along the lateral margins, inflated at the middle and reaching the level of the lateral margins of the dorsum.

Color.— Head hyaline, slightly suffused by the brown of the markings. Bases of the hairs very slightly darkened with brown which gradually deepens until the color becomes umber. A sooty blotch is present just below the eye. A deep suture along the median has a narrow suffused border. The central caudal margins of the thorax are clear and just beyond on each side are short bands of light chocolate-brown. From the eyes backward extends an irregular, broken line of a brownish color. The legs are tinged with brown.

The abdomen is hyaline with the regular lines of the thorax continued backward. The apical margins of the segments are almost clear, then darken, forming wide borders which enlarge below. *Length* 2 mm.-2.4 mm.

SECOND INSTAR: *Body* larger; rather strongly arched; the dorsal margin abruptly recurved. *Integument* finely punctured. The simple forked tuberosities have become spinose, with a ringed appearance. *Head* narrow; face flattened; vertex more compacted, causing an angular appearance between the eyes. Mouth parts directed strongly backward. Eyes compound, spines hardly conspicuous. Tuberosities complexly spined, usually with eight or nine hairs; bent strongly forward, often with the terminal hair inclined caudad.

The *prothorax* is inclined forward. The tuberosities are complex. The cephalad pair is the longest and most slender, and bends strongly forward. The terminal hair is shorter than that on the caudad tuberosities, which incline forward but do not curve.

The *mesothoracic* and *metathoracic tuberosities* are complex. Those on the former are the more slender and inclined forward; those on the latter are almost perpendicular and have the terminal hair curved.

The pair of hairs between the last thoracic and first *abdominal tuberosities* are simple and set on a rather long tubercle. The hairs are long, stout, and curved sidewise. The tuberosities are complexly spined, curve caudad gradually and more so than in first instar; those on the last segment are small with hairs above. This segment is strongly spinose and the tube has a fringe of stout hairs.

The margins of the *venter* are flat for some distance; median ventose. *Color,* hyaline, often faintly tinged with pale green, and slightly suffused with brown. Bases of hairs usually of a chocolate brown color. Several irregular splashes of brown are on the face. Eyes with a transverse irregular brown area and a sizable blotch of chocolate brown at the lower frontal margin. Prothorax with a transverse band of brown of some width starting just behind the eyes and extending caudad. Close to the median and about the bases the tuberosities are chocolate brown, and on the sides are dusky brown. The remaining thoracic segments are colored in a similar manner. The first two abdominal segments are deeply suffused with brown for almost one-half of each lateral margin, the remaining segments gradually clearing until the terminal segment is slightly suffused with brown in spots. The tuberosities are set in patches of dark brown which become fainter above. The bases of the spines are deeply suffused.

Legs with a large spot on each coxa and the apical margin of each trochanter. A wide band occurs near the apical margin of the femur, also spots on the tibiæ. The apical margins of the tarsi are brown shading to dark brown along the other margins. Venter clear. *Length* 2.5 mm.-3 mm.

THIRD INSTAR: *Body* wider; more strongly arched and having the tuberosities more strongly inclined forward, and considerably curved backward on the abdomen. *Head,* flat; mouth parts directed backward and continuing the concaved ventral margin of the abdomen. The tuberosities on the vertex are more slender, with longer spines than during the second instar, and curved to a greater degree than at that time. The eyes appear with a rather wide margin below.

Prothorax considerably raised and rounded, with the front compressed, on which are situated the first pair of thoracic tuberosities. At the apex behind the suture are the second pair of thoracic tuberosities. Directly caudad, on the median and at the posterior margin is a sizable nipple-shaped prominence which is directed backward. The lateral margins are flattened.

The *mesothorax* is compacted at the median. The tuberosities are longer than the other thoracic protuberances, are slender and armed with long spines; they incline slightly forward. The lateral margins of the segment are rounded, extending downward and backward to a blunt point.

The *metathorax* is much compacted with caudad margins rounded below, extended and slightly longer and more rounded than those of the mesothorax. The tuberosity is situated close to the margin of the preceding segment. It is rather short with the lower spines interlocking with those of the preceding tuberosity.

The *abdomen* is more completely covered with short spinous hairs. The tuberosities are more slender and strongly bent backward with the last complex pair often reaching the anal tube. The caudal tuberosity is armed with much smaller spines and reaches to the end of the anal tube extended. The ventral surface of the abdomen is more rounded and the spines are longer.

Color.— The various markings increase in density and occasional specimens exhibit a tendency to become lighter. *Length* 3.5 mm.-4 mm.

FOURTH INSTAR: Body more elevated, wider, and more strongly decurved. Tuberosities stouter, shorter, and more distinctly bent. Head usually set

below the plane of the venter, face flattened. Tuberosities stout, short, directed almost sub-horizontal. *Eyes* large, with margin rather wide.

Prothorax erect, sub-vertical in front. Tuberosities stouter and well inclined forward; the posterior pair at the apex of the segment. The nipple shaped prominence is not present on the caudal margin, which has become raised and rounded and projects over the succeeding segment almost to the tuberosities. The *mesothorax* and *metathorax* are raised. On the former the tuberosities are stout and arise close to the cephalad margin, and on the latter they project almost from the caudal margin. The *wing pads* are sizable.

The *abdominal tuberosities* are more strongly curved backward and more stocky than before. The last complex tuberosities may not reach the tip of the anal tube. Terminal projections almost simple, very short and with only two very small spines. *Ventrum* strongly inflated beyond the lateral margins. *Color*, usually a much deeper brown than before. *Length* 5-6.5 mm.

FIFTH INSTAR: *Body* thicker; dorsum of abdomen more strongly curved. *Prothorax* higher, projecting beyond the body, and much elevated. The caudal margin is more distinctly keel shaped, often slightly hooked and extending backward between the succeeding pair of tuberosities. The mesothoracic and metathoracic *tuberosities* small, inclined forward and reclining on the tip of the prothoracic keel. *Wing pads* very prominent, produced backward. The abdominal *tuberosities* are very small, bushy, and curved strongly backward.

Color.— Certain of the specimens became a much deeper brown, while others were noticeably lighter at this time. *Length* 7 mm.-8.5 mm.

HABITS OF ADULT: OVIPOSITION.

The eggs are usually inserted within the bark of two- or three-year-old growth. At the beginning of oviposition a slightly curved slit is cut through the outer bark with the ovipositor which at first is extended at right angles to the body, but which as the cutting continues is gradually elevated backward until at the end of the operation it rests almost on the abdomen. At the commencement of the process the body is elevated on its legs and vibrates sidewise, which motion becomes less noticeable, until at the end of the operation the abdomen rests on the bark. The eggs are then inserted. Commencing at that end of the slit just finished the ovipositor is forced through the bark to the cambium layer and at the same time the abdomen rests on the twig. At intervals of from ½ to 2 minutes the ovipositor is drawn forcibly forward often partly out of the slit and then reinserted. Subsequently another shorter slit is made which is parallel to the first and curves toward it. The eggs are inserted in a manner similar to that described for the previous slit. The introduction of the eggs is accomplished from the cut which is at the greater distance from the eggs.

1

2

PLATE XXIX.—TREES INJURED BY THE BUFFALO TREE-HOPPER.

1. Effect of severe pruning to remove injured wood.
2. Unpruned tree stunted by four years' attacks.

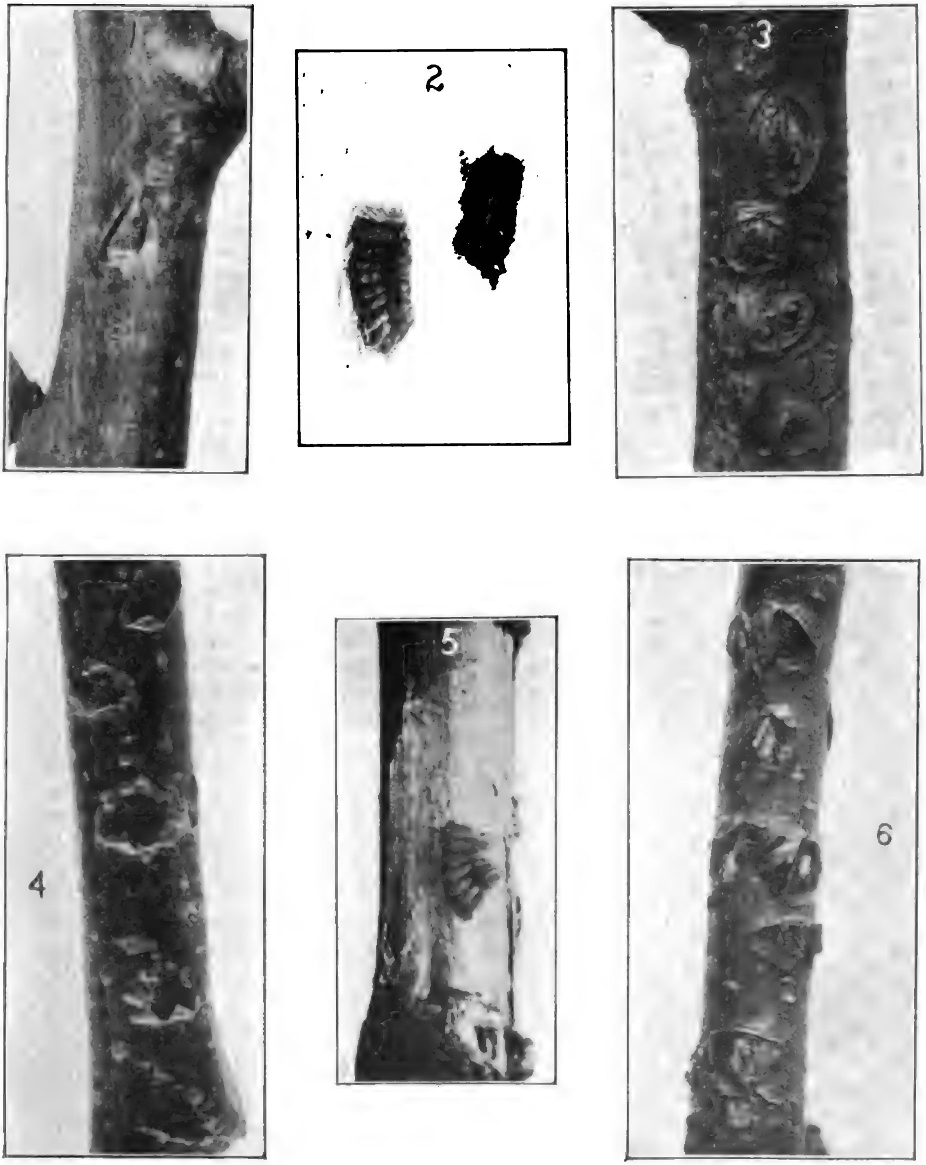

PLATE XXX.— EGGS, EGG-SLITS AND SCARS OF *Ceresa bubalus* FABR. AND *Stictocephala inermis* FABR.

C. bubalus: 1, Egg-slits; 2, egg-mass; 3. old wounds. (Enlarged.)
S. inermis: 4, Egg-scars; 5, egg-mass; 6, old wounds. (Enlarged.)

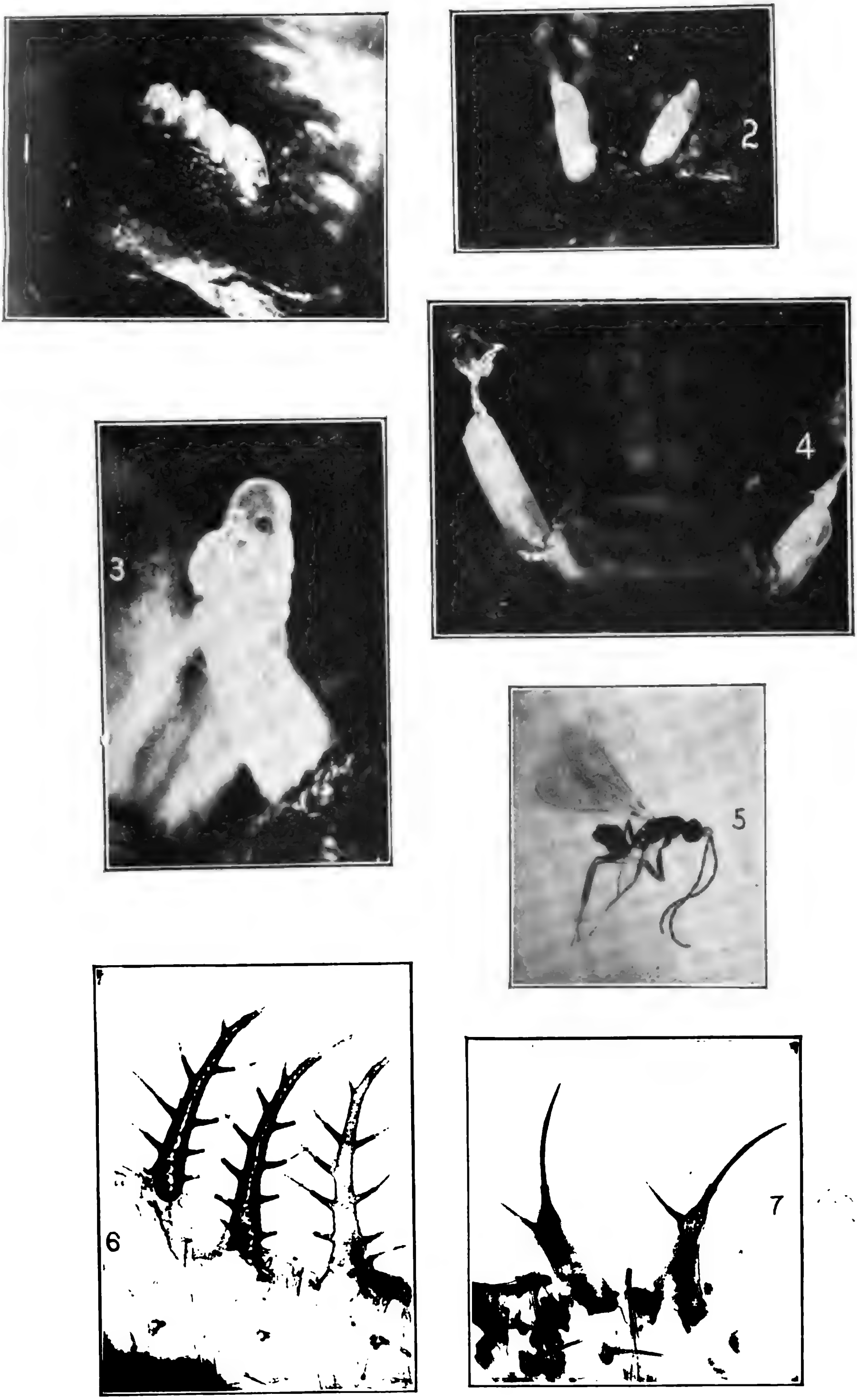

Plate XXXI.—Life-Stages of *Ceresa taurina* Fitch and Tuberosities of *C. bubalus* Fabr.

C. taurina: 1. Eggs in bud; 2. egg-cap protruding; 3, nymph hatching; 4. egg-shells showing cap; 5, egg-parasite, *P. striaticorne* Gir.

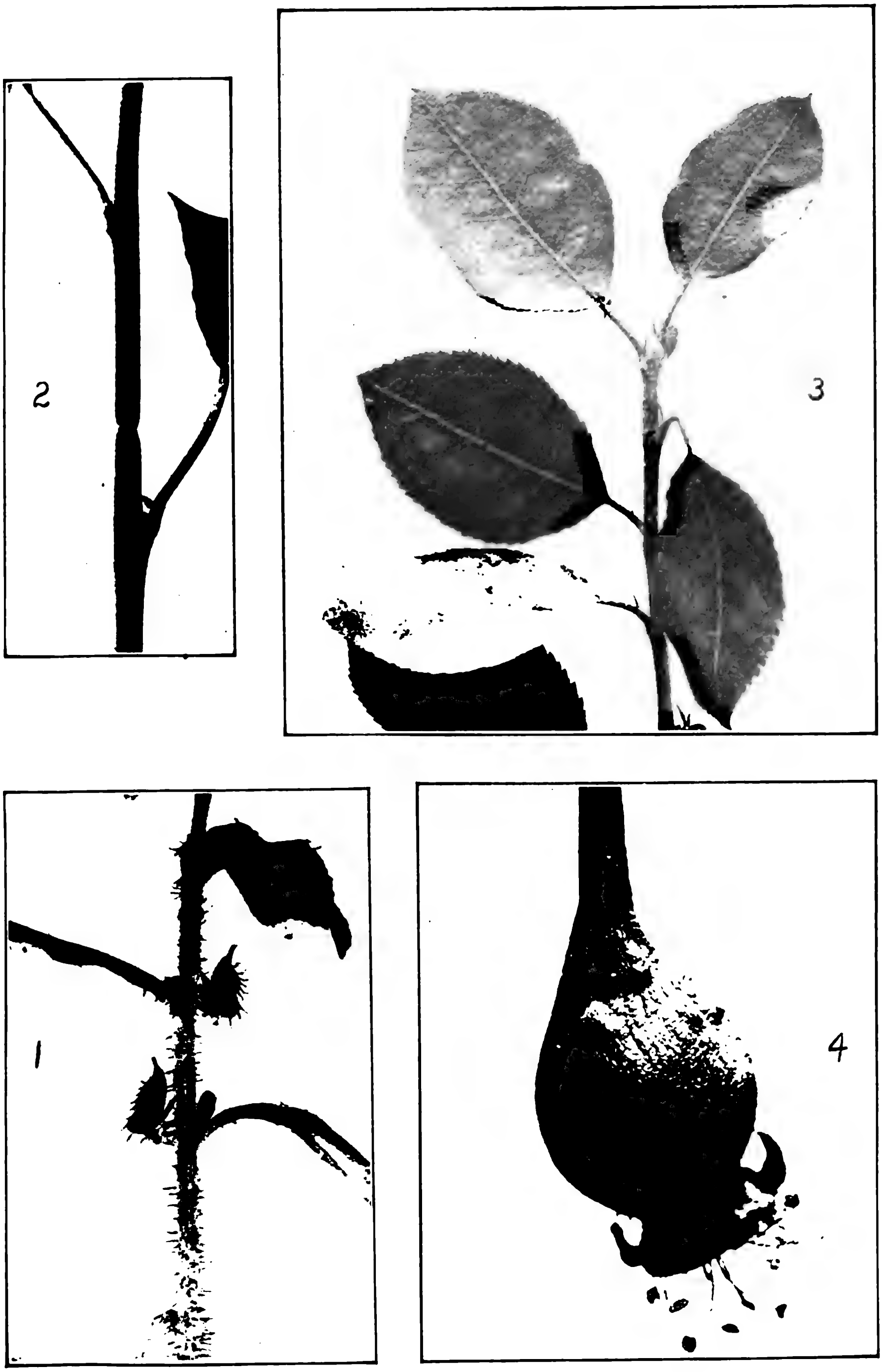

PLATE XXXII.—FEEDING HABITS OF NYMPHS OF *C. taurina* FITCH.

1, Nymphs on weed; 2, girdling of pear shoot; 3, girdling of leaf petiole; 4, pimpling of fruit.

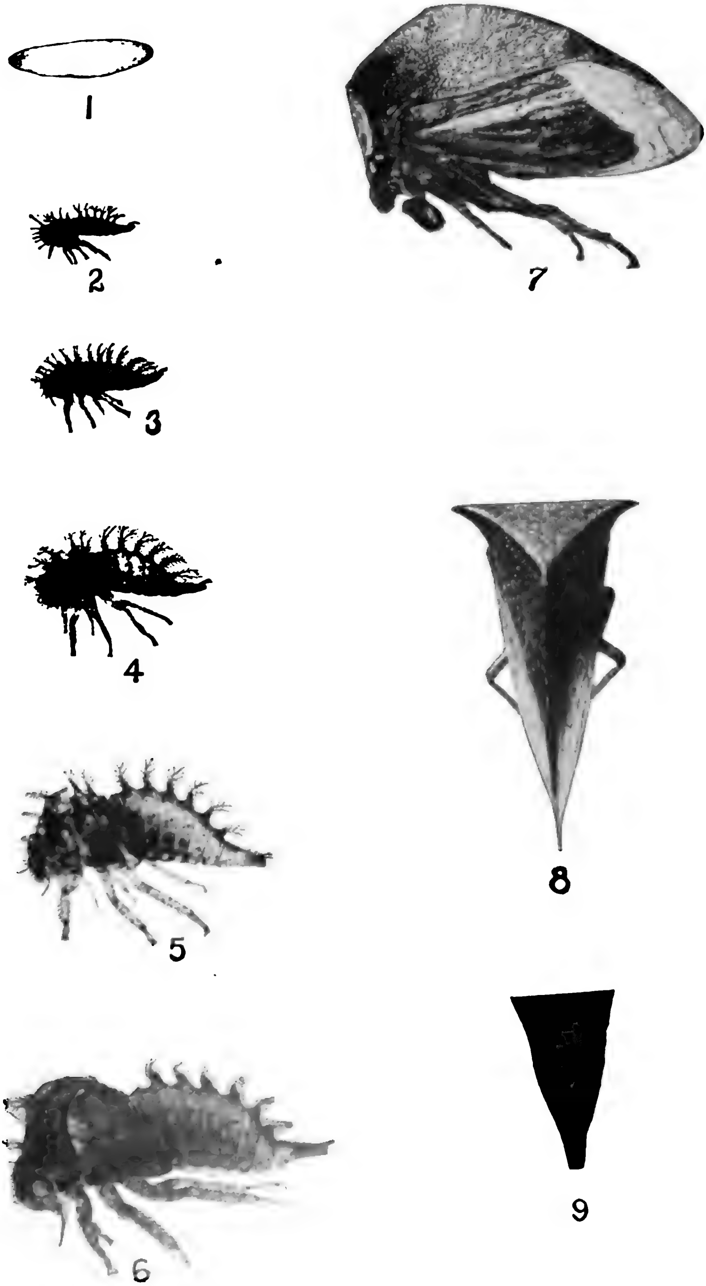

PLATE XXXIII.—LIFE STAGES OF *Ceresa bubalus* FABR.

1, Egg; 2–6, nymphal stages; 7 and 8. lateral and dorsal views of adult; 9, last ventral segment of female. (Enlarged.)

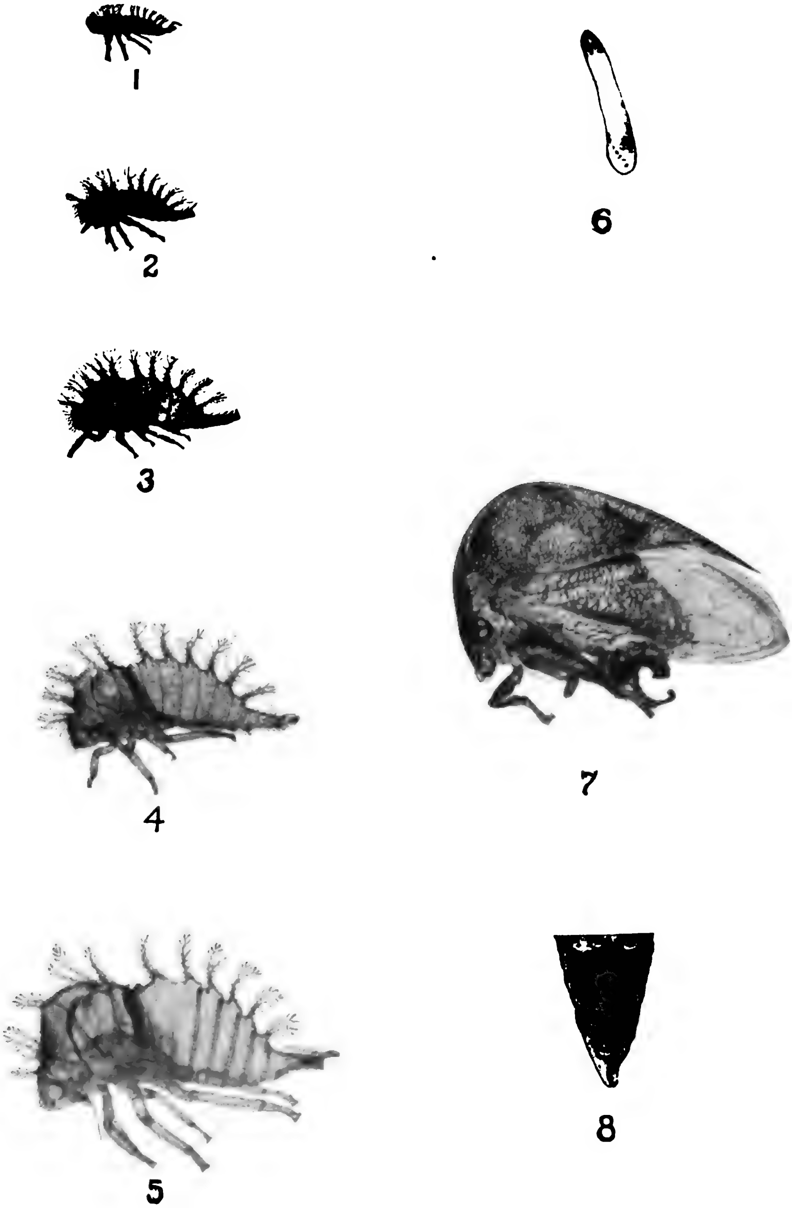

PLATE XXXVI.— LIFE STAGES OF *Stictocephala inermis.*

1–5. Nymphal stages; 6, egg; 7, adult. lateral view; 8, last ventral segment of female. (Enlarged.)

The time occupied for the completion of each slit and the placing of the eggs is from 20 to 25 minutes and the number of eggs varies from 6 to 12 in a slit.

DESTRUCTIVENESS.

This is the most injurious of the tree-hoppers that are known to oviposit on fruit trees. The injury to the bark between each pair of slits does not heal and intercepts the growth at this point. With each subsequent year's development the scars enlarge, assuming an oval shape from the center of which the dead wood becomes detached. Several successive attacks of the insect considerably roughen the bark and provide a convenient place for the activities of wood-boring insects. Limbs of trees injured in this manner become much weakened and break under severe strain. Marlatt refers to an interesting infestation of this kind which was brought to his notice by the superintendent of Lincoln Park, Chicago.[7] This occurred on the smaller branches of the cottonwood, *Populus monilifera* Ait. (*deltoides* Marsh), which dropped in large numbers owing to the attacks of a boring beetle. An examination of such wood indicated that it had been previously injured by the buffalo tree-hopper. These old scars provided a favorable place for the deposition of the eggs of *Oberea schaumii* Lec., the larvæ of which burrowed up and down the twigs, weakening and causing them to drop. The most serious effect of repeated injuries by *C. bubalus* is that the bark becomes inelastic, causing the weakening and dwarfing of the trees.

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[7] Kans. Acad. Sci. 10:84. 1886. *Ins. Life*, 7:8–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. 23, 2d Ser. 1897.

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CERESA TAURINA FITCH.

HISTORICAL.

The earliest record of this insect as a distinct species was made by Harris in 1833.[15] Later Walker listed it as *Enchenopa taurina* in the List of the Homoptera of the British Museum, published during 1851.[16] The description which gave Fitch the credit for the species appeared in 1856.[17] In 1873 Riley described and figured egg-punctures and nymphs as those of *Ceresa bubalus,*[18] which Marlatt later found to be incorrect[7] and Riley subsequently referred them to *Ceresa taurina* Fitch.[19] Marlatt in 1894 accepted the correction and included a figure of *C. taurina* Fitch., showing the peculiar egg slits which have since been accepted as being made by this species.[7]

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15 Cat. Ins. Mass. 1835. p. 579.
16 List. Hom. Brit. Mus. 1851. p. 495.
17 Rpt. Ins. N. Y. 3:335. 1856.
18 Rpt. Ins. Mo. 5:121. 1872.
Our studies on this insect indicate that Riley was misled into believing that the membracid nymphs were hatched from such scars, and that he obtained the young tree-hoppers from eggs which were in the buds of the wood used for rearing the insects. The oviposition he mentioned is accomplished by our common, larger leaf-hoppers. Among these may be mentioned *Gypona cana* Burm., and *Gypona octolineata* Say.
7 Kans. Acad. Sci. 10:84. 1886. *Ins. Life,* 7:3–14. 1894. U. S. Dept. Agr. Bu. Ent. Cir. 23, 2d Ser. 1897.
19 *Proc. Ent. Soc. Wash.* 3:88. 1892.

TECHNICAL DESCRIPTIONS.

ADULT.

Pronotum elevated as in *C. bubalus* and sparsely hairy; metopidium transversely distinctly concave; suprahumerals more terete than in *bubalus*. and very acute, sloping upwards and strongly curved backwards; surface rather coarsely and evenly punctate with median carina more distinct than that of *bubalus*; anterior margin less deeply sinuate, with angles more rounding than those of *bubalus*; callosities plainly distinguished; posterior portion narrowing more gently than in *bubalus*, and with the produced tip less strongly curved downward, but with the tip strongly recurved. *Head* large, not produced between the eyes; anterior margins of cheeks stranght; not reaching the apex of the tylus; tylus large, more acutely angular and extending back more than in the previous species, and with the apex longer than the cheeks and loriæ; anterior margins acutely angular and continuing the outline of the head. The last *ventral segment* of the female is much longer than in *bubalus;* the outer hind angles are rounded and much advanced beyond the last segment of the connexivum, with the edges strongly oblique and slightly arcuated to the acute median notch. The *plates* of the male are somewhat narrower than in the foregoing species and scarcely attain the tip of the anal tube.

Color.— Green, more or less flavous in preserved specimens. Prothorax distinctly mottled with white which is more noticeable than in *bubalus* in which the spots are more coalesced. Wings hyaline, more faintly testaceous at apical margins than in the preeeding species. *Length* 8–10 mm.

EGG.

Tooth shaped; elongated; compressed laterally; one lateral margin very slightly incurved, nearly straight, and abruptly curved to meet the opposite side of the base. The other lateral margin is abruptly sub-angular near apex; strongly convex near the middle and recurved strongly near the base which is bluntly rounded; the apex is flat. *Chorion* white, vitreus, sculptured; sculpture showing as fine anastomosing lines. *Cap* in the form of an inner shell which protrudes through a lateral apical suture as the embryo develops. *Suture* distinct; appearing well down to the embryonic eye in advanced individuals. *Size:* Av. length 1.5 mm. Av. width .4 mm. Just before hatching the eggs are 2 mm. in length.

NYMPH.

FIRST INSTAR: *Body* small; narrow; widest at eyes; narrowing at first abdominal segment and from thence gradually to the tube. Prominent simple and forked tuberosities are borne as usual on each side of the median of the several segments. *Head*, medium; well rounded, somewhat compressed laterally; face and mouth parts not directed as strongly downward and backward as in *bubalus*; integument roughened, without microscopic hairs. Several regularly placed, long hairs arise from the head and its appendages and originate on sizable nipple-shaped tubercles. The first pair of tuberosities (on the vertex) are simple and lack the spinous hairs which occur on tne nymphs of *bubalus*, and which give then a ringed appearance. The tuberosities appear to be roughened but not ringed. On the eye are situated two sizable hairs which are near to each other and and to the forward margin.

The *prothoracic tuberosities* are simple, the cephalad pair being somewhat more slender than those preceding, while the other pair has a small spine arising from just below the base of the terminal hair.

The *mesothoracic tuberosities* are stouter than the preceding pair and the forward hair is longer and arises from a distinct fork, laterad and below which is a single short spine.

The *metathoracic tuberosities* are as usual, and have a slender, laterocaudal spine near the base.

Spines and hairs.— On the first abdominal segment no spines are present. The second segment has a pair of simple hairs, and the other segments have the forked tuberosities as usual. On the anal tube the tuberosities are simple and bear near the base two hairs of about equal length, opposite, caudo- and cephalolateral respectively. The extrusible tube has a fringe of rather coarse hairs. Extending across the thorax and abdomen are three rows of long simple hairs.

The legs are clothed with hairs as usual.

Color.— Vitreus, transparent; tarsi tinged with fuscus; no markings on body. *Length* 1.5 mm.-2 mm.

SECOND INSTAR: *Body* longer, arched, and having the dorsal margin of the abdomen strongly rounded and not usually recurved. Integument finely punctured The simple forked tuberosities have become compound, with several spines arising from the sides, and having a ringed appearance near the apices. *Head* large; face round; vertex angular, flattened above the eyes. Eyes compound, spines situated rather closely together at apex. Mouth-parts directed downward. Tuberosities rather long and slender with one short hair on the forward margin and two smaller hairs near the center of the hind margin. The tuberosities are bent forward and the terminal hairs curved backward.

Prothorax not noticeably inclined forward. The tuberosities are complex, with two or three spines cephalad and two caudad. The terminal hairs are of the same length and may bend toward those in front or be perpendicular.

The *meso-* and *metathoracic tuberosities* are complex, usually with a greater number of spines than on those preceding and having the terminal hairs curved or erect.

The first median abdominal projections are simple hairs, which are very small.

The first pair of *tuberosities* has one spine on its caudal surface, the second has one spine caudad and opposite to it is a rather long lateral hair; the next three pairs have two spines on the caudal margin, while the last pairs of tuberosities have three spines in a similar position. The tuberosities gradually curve until the last pair is considerably bent, and these extend backward for about three-quarters of the length of the anal tube. The anal tuberosities have two small hairs on the margins which extend backward almost parallel with the tube and are slightly curved upward with the terminal hair strongly recurved. The last segment has on its surface several rows of regular slender spines; it is not spinose. Venter as usual.

Color.— Pale green on head and body, the appendages being translucent. *Length* 2.5 mm.-3 mm.

THIRD INSTAR: *Body* longer and wider; tuberosities considerably curved forward and backward. *Head* much compressed cephalo-caudad; vertex narrow, angular. Mouth parts usually directed backward. Tuberosities on the vertex are slender, strongly curved forward and downward and with spines few in number. The eyes are as usual with apical hairs hardly conspicuous.

Prothorax considerably raised, with forward margin inclined cephalad and bearing the second pair of tuberosities which are longer than the preceding and only slightly less strongly curved. Behind and at the apex of the segment is the third pair of tuberosities which are only slightly

curved; the spines are slender. Directly caudad, the median is slightly raised to the margin and not considerably elevated as in *bubalus*.

Mesothorax not compacted; caudo-lateral margin extending backwards. The tuberosities are somewhat more slender than those preceding, incline forward and are situated at the caudal margin.

Metathorax not compacted; caudal margins strongly rounded from about the middle, to form the wing pads. The tuberosities are at the margin of the preceding segment and are about the same length and curved slightly backward at the tip.

The abdomen is covered with minute spines and bears long hairs only at the ventral margins. The median pair of hairs has become nearly obsolete. The first pair of tuberosities is strongly curved forward and bent backward while those behind are strongly curved, caudad, the last pair reaching the tip of the anal tube. Ventral surface as usual.

Color.— Pale green; caudal margins of the abdominal segments with a prominent band of a burnt Sienna tint. Legs, femur and tibia hyaline with a strong tinge of green cephalad; the tarsi have a strong dusky tinge. The tuberosities have become dusky or nearly so. The color is sharper and well defined from that of the food plant. *Length* 3.5 mm.–4 mm.

FOURTH INSTAR: *Body* more elevated and strongly curved. Tuberosities more slender and strongly curved behind and inclined forward. *Head* situated above the plane of the venter; much compressed. Eyes large, forward hair prominent, the other hardly visible.

Prothorax higher, with horn distinct and projecting backward; not rounded. The first pair of tuberosities situated at the cephalad margin, and well bent forward; the posteror pair is at the apex of the segment and is inclined toward the head. *Mesothorax* larger, compressed at the median with the tuberosities inclined forward and curved upward at the tips. *Metathorax* of good size with the tuberosities slender, inclined forward, and with the apices curved back. *Wing pads* strong.

Abdomen without spines and with the first pair of median projections nearly obsolete. The tuberosities are slender and strongly curved, the last pair not reaching the tip of the anal tube. The terminal projections are stout and directed backward and upward. It has several hairs on the surface. The venter is strongly rounded and spinose.

Color, pale green, concolorous. The tuberosities and spines of the head are black. Those of the prothorax black at the tips. The meso- and metathoracic spines are clear faintly suffused with black, while the abdominal spines are clear excepting the three caudal pairs which are black at the tips, the last pair being entirely black. The legs are light green with tarsi of a deep dusky tinge. The amber colored margins are prominent but narrow. *Length* 5 mm.–6.5 mm.

FIFTH INSTAR: *Body* very much longer; *head* for the most part projecting below the line of the body; tuberosities of good length and stout, usually bent down. The spines on the eyes are present and situated forward. *Prothorax* nearly erect and curved backward to the second pair of tuberosities which are situated at the caudal margin and are strongly curved. The *posterior margin* is distinctly keel shaped and extends considerably caudad between the *tuberosities of the methathorax* which incline strongly forward but do not recline on the tip of the keel. The *abdominal tuberosities* are long and slender and curved strongly backward, the last pair being almost level with the tube. The *anal tuberosities* are short, point upward and backward and have several lateral and ventral spines. *Color.* pale green with a deeper green tinge. The bases of the spines deeper green and the tips are black. The anal segment slightly tinged with fuscous. Legs hyaline with a greenish tinge and the tarsi somewhat suffused. The prothoracic horn is tinged at the tip with amber and the mouth parts are suffused with green. *Length* 7 mm.–7.5 mm.

HABITS OF THE ADULT: OVIPOSITION.

The eggs of this species are deposited usually in buds of trees that are in bearing. In selecting a nidus for the eggs, the female commonly chooses the blossom buds or the more swollen terminal buds. The eggs are inserted within the outer bud scale and rarely inside of the second scale. They are placed perpendicularly and close together, with the margins contracted, and usually in rows of from four to six eggs. Quite frequently two or even more short rows occur in a fruit bud, with often but two eggs together. It is not uncommon to find a single egg within one bud scale, either alone or separated from others in the same bud.

Oviposition is accomplished by the thrusting of the ovipositor between the bud scales and for some distance into the tissue at the base of the bud. The eggs are then placed in position and are firmly attached to the wood. About one-fourth of the egg is encased in the tissue, the remainder protruding freely and being entirely protected by the bud scales.

DESTRUCTIVENESS.

The incisions made within the buds by this species should, apparently, seriously affect the new growth. No injurious effects have been noticed even where the eggs have been numerous enough to encircle the bud.

In the breeding cages adults fed upon pear fruits, causing the surfaces and stems to become considerably elevated around the feeding punctures. Under ordinary orchard conditions such injuries will not be noticed.

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CERESA BOREALIS FAIRM.

HISTORICAL.

Since the time of Fairmaire, most writers have mentioned this species as a synonym of *C. bubalus* Fabr. The original description appeared in 1846,[20] from which date we have little published data concerning this very common insect. Our recent studies show that the species is distinct in its habits and taxonomic characters.

TECHNICAL DESCRIPTIONS.

ADULT.

Pronotum not as highly elevated as in *bubalus* or as in *taurina*, and more hairy than the latter; metopidium transversely flat; suprahumerals rather long, terete or nearly so. Surface finely, evenly, punctate. Carina not as prominent as in *taurina*. Anterior margin deeply sinuate as in *bubalus* and subangulate at the eyes. Callosities plainly distinguished. Posterior portion narrowing gently, strongly recurved and short but reaching tip of abdomen. *Head* small, not produced between the eyes. Anterior margins of cheeks slightly rounded reaching the apex of the tylus, which is large. Clypeus triangularly produced beyond the line of the cheeks. The last *ventral* segment of the female a little longer than the sixth segment of the connexivum, which is rounded. The posterior margin is slightly oblique and feebly rounded or truncated on both sides of the broad, triangular, median notch. The plates of the male reach the tip of the tube. *Color* dark green, flavous in preserved specimens. Prothorax distinctly spotted with white which is more apparent on the sides and is somewhat coalesced between the eyes. Wings hyaline somewhat testaceous at apex. *Length* 7–8 mm.

[20] Ann. Soc. Ent. Fr. 4:284. 1846.

EGG.

Tooth-shaped; elongated; compressed; rather strongly incurved along one margin which is distinctly recurved to meet the opposite side at the apex; opposite surface strongly convex to the rather sharply pointed apex; base bluntly rounded. *Chorion* white; vitreus; sculptured; *sculpture* appears as delicate pentagonal markings. *Cap* within shell at apex; protruding through a sizable apical suture as the embryo becomes mature. *Suture* distinct; base extended almost to the middle of the margin. *Size:* Av. length 1.3 mm. Av. width 0.3 mm.

NYMPH.

FIRST INSTAR: *Body* hardly as long or as stout as in *taurina*. Body widest at the thorax, gradually narrowing to the tube which is smaller than in the preceding species. *Head* rounder and more ventose. The tuberosities are about the same in size but with the terminal hairs and branches more finely pointed. The spines on the eyes are situated at the top and somewhat forward. The third spine of the *mesothoracic tuberosities* is situated lower on the margin than on *taurina*. The *caudal tuberosities* are more slender and have the spines nearer to the base than the above species. The apices of the tuberosities are ringed. The venter is as usual. *Color,* hyaline, with areas of reddish brown on the head. The thoracic margins somewhat tinged and the lateral angles and bases of the longer hairs more strongly colored. The abdomen is slightly tinged with reddish brown and the bases of the larger hairs are strongly suffused. The tuberosities are slightly tinged with fuscous which is deeper at the base. The legs have a band of fuscous just behind the apical margin of the femur, and the tibia is spotted. *Length* 1.4 mm.–2 mm.

SECOND INSTAR: *Body* somewhat stouter; tuberosities bushy; segments spinose more like *bubalus*. Head not compressed, ventose, spinose, and not projecting below the line of the body. Tuberosities slender and bushy. *Prothorax* considerably raised but not as highly arched as in the preceding species. Tuberosities close and not as strongly curved as on *taurina*. *Mesothoracic tuberosities* at the caudal margin rather stout at the base and extending almost directly upward. The *metathoracic tuberosities* are situated on the middle of the segment and usually interlock with the preceding pair. The simple hairs on the median of the abdomen are sizable and stout. The tuberosities are more strongly ringed and curved slightly back near the apex. The *caudal tuberosities* are stout and strongly curved, the last pair often reaching the tip of the tube. The anal pair are more tapering than in *taurina*. The *integument* is coarse and spiny. The legs are spinose and the venter is swollen. *Color,* hyaline; head with brownish spots at the base of the larger hairs with the darkened area extending over the head. Prothoracic lateral angles deeply suffused and with a distinct brownish band extending backward over the abdominal segment. The margins of the mesathorax are the same with a clear area between them. The color becomes lighter and the last abdominal segment is clear. The tuberosities are suffused, their bases being deeper. The median of the anal segment is suffused and the tip is dark. The legs are spotted and tinged with brown. *Length,* 2.5 mm.-3 mm.

THIRD INSTAR: Body much smaller than *taurina* and less abruptly curved. Tuberosities more strongly inclined forward and those behind are about the same. *Head* subangular, flat, compressed laterally. Mouth parts directed backward. Tuberosities short and bushy, intermingling with the hairs on the vertex. Eye spines stout. *Prothorax* arched, tuberosities finer and shorter than those of *taurina*. *Meso-* and *metathorax* compacted, with the tuberosities rather short, tapering and intermingling. Abdominal median

hairs small and stout. The tuberosities bushy, curved caudad and having the hind pairs intermingling with each other, and the last pair intermingling with the median spines of the anal tube. *Caudal tuberosities* long and slender and more erect than in *taurina*. Three rows of spines cross the sides of the abdomen the ventral margins of which are spinose. *Color.*—The head, thorax and abdomen have a marginal suffusion of brownish black especially in the caudal angles. A distinct band of the same color, varying in density crosses the abdomen on both sides. The tuberosities are slightly tinged with the same color. *Length*, 3.5 mm.–4 mm.

FOURTH INSTAR: *Body* longer; thicker than *taurina*. *Head* spinose; tuberosities not curved, but directed outward and upward. *Prothorax* more erect; not higher than the body; tuberosities stocky, bushy, and inclining forward; horn pronounced, not as distinctly elevated as in *taurina*. *Mesothoracic* and *metathoracic tuberosities* closely intermingling and inclined cephalad. *Abdominal tuberosities* rather slender and bushy, but do not interlock; the last pair being almost parallel with the anal tube. *Anal tuberosities* short, slender, and having one spine above and three spines beneath, but without the basal spine as in *bubalus*; the alternate spines are somewhat more lateral than ventral, as in *taurina*. *Venter* swollen, lobes prominent. Abdominal margins spinose. *Color*, head and prothorax dark brown entire. Face less densely brown to hyaline. Mesothoracic caudal margins brown, becoming less dense cephalad; angles clear with suffused areas. Metathorax faintly suffused near and to the tuberosities. Abdominal band deeper brown, becoming less deeply colored caudad. Caudal margin of last segment, median of abdomen, and the tuberosities more or less deeply suffused. *Length*, 5 mm.–5.6 mm.

FIFTH INSTAR: *Body* large; *head* small, projecting somewhat below the body. The tuberosities on the vertex almost atrophied, and the simple hairs are longer. *Prothorax* vertical, considerably raised; horn large, strongly curved, and reaching the *metathoracic tuberosities* which are short, fine and inclined cephalad. They recline on the *mesothoracic tuberosities*. *Abdominal tuberosities* close together at the base, stout and those cephalad leaning forward while the remaining ones are curved caudad and are short. The anal pair are short and fine. The *wing pads* are strong. The *legs* are spinose. *Color*, deep brown. The surface is almost entirely suffused and within are small areas of hyaline or greenish tinge. The cephalad segments of the abdomen are deeply suffused at the anterior margins. Large dark areas occur beneath the eyes, the thorax, and on the legs. The tuberosities are deeply colored. *Length*, 6 mm.–7 mm.

HABITS OF THE ADULT: OVIPOSITION.

This species oviposits in the buds of the trees in a manner similar to that of *C. taurina*. Occasional instances have been noticed in which the younger wood seemed to be preferred for this purpose. In such cases the eggs were placed between the buds and the portion of the stem immediately behind the bud.

The deposition of the eggs is accomplished by the same process which has been described for *C. taurina*. The only external differences by which the eggs of the two species may be recognized is in the greater depth to which those of *borealis* are

inserted, and their slightly smaller size. The effects of the punctures on the buds seem to be of little consequence.

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STICTOCEPHALA INERMIS FABR.

HISTORICAL.

The original description of this species was published in 1794 by Fabricius.[21] From that date occasional records of the occurrence of the insect appeared, until 1856 when Fitch made a reference to the egg slits and eggs of this species.[22] Subsequently a number of writers have mentioned the species and have given a taxonomic discussion of the adult, but apparently no description of the habits of the insect has been published. It is not uncommon to find figures of the peculiar egg scars of this species illustrating an article on *Ceresa bubalus*. Injuries to the bark by *S. inermis* are so characteristic that there is no occasion for confusing them.

TECHNICAL DESCRIPTION.

ADULT.

Face large and impunctate; surface finely and closely striate between the ocelli and the eyes. Clypeus and loriæ short and rounded at the apex and very nearly continuing the arcuated cheeks. Metopidium obviously widening above to rounded suprahumerals. *Femora* generally black above, which marking is occasionally absent. The last *ventral segment* of the female broadly, and angularly, but not deeply excavated behind. *Wings* rather strongly suffused at apex. *Color* of prothorax and abdomen green. Appendages lighter. *Length,* 6.5 mm.-9 mm.

EGG.

Wedge shaped; elongated; cylindrical; compressed laterally toward apex; broadly expanded below; abruptly narrowed at base which is bluntly

[21] Ent. Syst. 4:15. 1794.
[22] Rpt. Ins. N. Y. 3:360. 1856.

wedge shaped; margins more or less strongly curved. *Chorion* vitreus; transparent; white; apex deep purple in well developed specimens. *Size:* Av. length 1.5 mm. Av. width 0.4 mm.

NYMPH.

FIRST INSTAR: *Body* long; rather more like *bubalus* than *taurina* or *borealis*; widest at the eyes. *Head* somewhat compressed cephalo-caudad, oblique and rounded; mouth-parts directed downward and backward. Eyes with three spines situated near the margins. Hairs on the face long and stout and curved forward. Tuberosities stout and unbranched, and becoming noticeably contracted at the apex to form a sizable collar from which arises the terminal hair. At the apex the tuberosities are rather coarsely, minutely spined, which gives the appearance of a series of rings. *Prothorax* wide; the forward tuberosities are not branched and shorter than the second pair, which are long and stout. The *mesothoracic tuberosities* are stout and have a very long spine just below and laterad of the fork. *Metathoracic tuberosities* noticeably swollen at the fork and bear a fine spine at the base. The median abdominal *hairs* are long, reaching almost to the fork of the succeeding tuberosities, which are as usual. The terminal hairs on the tuberosities are strongly curved caudad, the last pair overreaching the anal tuberosities, which bear two opposite spines near the base. The hairs of the upper abdominal row are unusually long. *Color.*— Head deep purplish brown, appearing almost black to unaided eyes. From prothorax backward is a distinct band, which becomes fainter caudad. The tuberosities are more or less suffused. The body is for the most part hyaline. *Length* 1.5 mm.–2 mm.

SECOND INSTAR: *Body* longer; tuberosities complex. *Head* compressed cephalo-caudad; rounded between the eyes; spinose; eye spines less prominent; tuberosities rather slender, strongly ringed, and more noticeably swollen at the base than during the first instar. *Prothoracic tuberosities* equally long, strongly ringed, and with the branches long and stout. The *mesothoracic* and *metathoracic tuberosities* are about the same in size as those preceding. The median abdominal *hairs* are short and the tuberosities are almost straight cephalad, and inclined gently behind with the last pair overreaching the anal tuberosities, which are of a medium size and slender, with two short, fine spines near the middle. Anal tube and body strongly spined. *Venter* as usual. *Color.*— Body hyaline, somewhat vitreous. Head and prothorax darker than before. The remaining segments are more or less spotted and diffused with the same color. The tip of the tube and the tuberosities for about half their height are slightly infuscated. *Length,* 2.5 mm.-3 mm.

THIRD INSTAR: *Head* somewhat compressed; ventose. Dorsal margin as usual. *Prothoracic tuberosities* long and stout. Caudal margin of prothorax distinctly raised. Tuberosities of *mesothorax* and *metathorax* tapering; spines intermingled; tuberosities spinate not arboriform; inclined forward. Abdominal *hairs* short and stout. Tuberosities long; stout at base; curving gradually backward; the last pair does not overreach the anal pair, which are small. Body spinose. *Color.*— Hyaline to pale greenish tinged; face strongly testaceous; anal tube darker at tip. Tuberosities testaceous; legs clear or faintly tinged. *Length* 4 mm.

FOURTH INSTAR: *Body* strongly curved; large; very spinose. *Head* partly below the line of body; compressed; vertex sloping; mouth parts angular. *Prothorax* well erected, the second pair of tuberosities at its apex; they are spinate. The next four *tuberosities* are stout, and their spines intermingle. Median abdominal spines not noticeably different from other spines on abdomen. Tuberosities long; slender; curved backward. *Color.*— Strongly testaceous on head and median of thorax; otherwise body hyaline or more or less strongly tinged with green. Tuberosities faintly suffused. *Length* 5 mm.-5.5 mm.

FIFTH INSTAR: *Body* large; strongly undulated along the median; spinose. *Head* rounded, ventose; sometimes flattened; tuberosities small, stout, spinate. Eye spines numerous. Prothorax elevated; keel sharply rounded; hooked; spinose; tuberosities long, slender, curving forward in front while those behind curve back at the apex. Other thoracic segments of good size with the tuberosities leaning forward. *Wing pads* of large size. Abdominal tuberosities long, slender, spinate, and curve more or less strongly caudad; anal pair slender, of good size, and point directly backward. Tube and abdomen strongly spinose. *Venter* round. *Color*, faintly testaceous on head and front of pronotum. Tuberosities often faintly suffused. Body hyaline or strongly pale green. *Length* 7 mm.–8 mm.

HABITS OF THE ADULT: OVIPOSITION.

When ready to oviposit the female selects a twig of two- or three-year-old growth and slits the outer bark diagonally for a short distance. The ovipositor is then thrust for its entire length beneath the bark, usually directly across the stem, which raises the epidermis above the surrounding tissue. The ovipositor is then partly withdrawn, moved forward, and again inserted; this time at a somewhat different angle. There is now formed a thickened basal portion with two digits. The process continues with the angles of radiation widening until four or five incisions have been completed. The primary slit remains about the same in length during the entire operation. The result of this work is the production of a scar very similar to a metacarpus with its digits rather widely extended. The epidermis raised by this process is distinctly lighter than the surrounding tissue and is of a yellowish color. As the season advances the tissue thus loosened becomes partly or entirely free from the uninjured epidermis and gradually rolls or is entirely freed from the stem. By this time the bark beneath the "palm" has blackened, and become corky.

After the epidermal layer has been loosened, a more or less oblique incision is made through the bark to the wood. This slit is fan shaped, rather narrower than the "hand" and is situated directly beneath the broad portion of the scar. The base of the cut does not reach to the digits.

The eggs are inserted after the completion of the slit. Each is placed separately, and those succeeding are put close together with bases wide apart and apices compressed to fill the neck of

the incision. The eggs are entirely concealed by the toughened bark above, and the opening of the slit is only slightly noticeable.

The numbers of the eggs deposited within each nidus is somewhat variable. The average number appears to be eight although three have been found in many instances. In any case the number of eggs to a single slit bears a definite relation to the digits of the exterior scar. The larger the number of fingers on the "palm," the greater the number of eggs which are beneath.

DESTRUCTIVENESS.

The abundance of this species and the numbers of the scars which māy be found on the twig would lead one to believe that it is capable of doing considerable damage. But examinations of the wounds of *S. inermis* made during the advancing season showed that such is not the case, for the inner tissue continues alive and there is not the dead area between the slits which occurs in the scars caused by *bubalus*. Trees which have been repeatedly cut by *S. inermis* do not exhibit the cumulative ill effects commonly noticed from the work of the buffalo tree-hopper. The wounds may be observed throughout the season following oviposition, or even later, but they apparently do not materially affect the growth of the tree.

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GRAPE INVESTIGATIONS IN CHAUTAUQUA COUNTY.*

The Legislature of 1909 provided for the investigation of the conditions of grape production in Chautauqua county and designated the New York Agricultural Experiment Station as the agency to do this work. For several years the output of grapes from this county had been steadily diminishing and it was feared by grape growers that the leading industry of that section of the State was in danger of becoming extinct. As the legislative act authorizing this investigation was not signed until April 22, 1909, it was not possible during the first season to organize extensive plans and set them in operation. The best that could be done was to establish headquarters, make a somewhat comprehensive survey of the situation and enter upon a limited amount of experimental work, the necessity of which was at once clearly indicated.

Two facts very soon became evident: (1) That the grape industry was not suffering from any single cause and no single remedy would rehabilitate it. The whole round of field practice including varieties, methods of culture, fertilizers and fungus and insect pests must be brought into the field of observation; (2) that the necessary experimental work could not be done in any one locality but must be distributed among those vineyards offering an opportunity to study the various important factors. Incidentally the generous crop of grapes harvested in the fall of 1909 demonstrated that the domination of the vine in sections of Chautauqua county was not at an end.

The first step taken was the establishment of headquarters at Fredonia. A lease was secured of thirty acres of land with a twenty acre vineyard owned by H. B. Benjamin of Fredonia, and a contract was entered into with Mr. Benjamin whereby he is to assist the Station in managing this particular experimental field. Because of the extent of the work to be undertaken it was at once decided that those members of the Station staff assigned to

* Letter of transmittal of Bulletin No. 331.

the immediate charge of the details of this work would necessarily locate in the midst of the field of operations during the summer months. The following assignments were made:

Fred E. Gladwin, B. S., Special Agent.
Donald Reddick, Ph. D., Fungus pests.
Fred Z. Hartzell, M. A., Insect pests.

A culture experiment was instituted in the Fredonia field and as extensive and well planned studies of fungus and insect pests were begun as the short time for preparation permitted. In addition to this Mr. Gladwin made a somewhat comprehensive and detailed survey of the grape industry in the county.

The work during the season of 1909 emphasized the conclusion that in order to accomplish the desired results it would be necessary to establish a number of points of observation, some of which would not be fixed but would vary in location according to the opportunity that is offered to deal with infestations of the pests that are destructive to vineyards. In consequence the number and ranges of experiments were greatly enlarged during the past season (1910). The following list shows the location and character of the various pieces of work undertaken:

GRAPE CULTURE EXPERIMENTS LOCATED FOR SEVERAL YEARS.

H. B. Benjamin (leased land), Fredonia,	30	acres.
S. S. Grandin, Wesfield	5	"
Hon. Charles M. Hamilton, Ripley	2	"
James Lee, Brocton	2¼	"
Miss Frances Jennings, Silver Creek	4⅔	"
H. G. Miner, West Sheridan	2½	"

GRAPE INSECT EXPERIMENTS.

James Barnes....	Prospect Station..	Renovation of vineyard injured by root-worm..............	5	acres.
Louis Bourne....	Westfield.........	Rose-chafer control...........	11	"
F. J. Clouse......	Fredonia.........	Flea-beetle control............	1	"
H. L. Cumming...	"	Grape-blossom midge control..	1	"
Charles Horton...	Silver Creek......	Leaf-hopper control...........	10	"
S. J. Lowell......	Fredonia.........	Root-worm control...........	7	"
M. J. Sackett....	West Irving......	Root-worm control........... Leaf-hopper control...........	8	"
Charles Secord...	" "	Root-worm control........... Leaf-hopper control...........	8	"

The various culture and spraying experiments are seen to have covered 97½ acres of land. From some of these experiments results may reasonably be expected within a comparatively short time, as is indicated by the contents of the bulletin herewith published. Other parts of the work, particularly the culture experiments, must be continued for several years before safe conclusions will be possible. The Station desires to pursue a conservative policy in the formulation of conclusions. Indeed, this is the only policy that can be justified on any grounds whatever.

One very gratifying and promising feature of the Chautauqua county effort is the hearty and intelligent co-operation of grape growers with the Station in the prosecution of its work. Only through such co-operation can the largest measure of practical results be reached.

W. H. JORDAN,
Director.

PRELIMINARY REPORT ON GRAPE INSECTS.*

F. Z. HARTZELL.

SUMMARY

The Chautauqua grape belt is the most important grape region in New York State. The gradual decline in productiveness during the last decade, notwithstanding the fact that the acreage has been greatly increased, is due in part to the depredations of injurious insects which feed on the vines. A number of important insects have been studied during the past two years. This bulletin is a report of the studies on the grape flea-beetle, the grape-blossom midge, the rose-chafer, the grape root-worm and the grape leaf-hopper.

The grape flea-beetle is a small, steel-blue beetle which feeds on the swelling buds. The beetles appear during April and feed during the warmer days. Mating takes place during a period of nearly two months. Egg-laying extends over a period of nearly two and a half months, but the greatest number of eggs are laid during a month and a half extending from about May 1 to the middle of June. The eggs are laid in the canes of the grape. The number of eggs laid by a female was found to vary from 5 to 103. The eggs hatch the latter part of June and early July and the larvæ feed upon the foliage, reaching full development in about three weeks. The larvæ form cells in the ground and transform to pupæ in about three weeks. The adult beetles feed on the grape foliage and later in the fall seek sheltered places to hibernate. The most efficient spraying mixture is composed of 8 lbs. of arsenate of lead, 3 gals. of glucose, and 100 gals. of water. This is applied in the spring as the beetles are feeding on the vines. The use of the same spray will kill the larvæ if applied the first part of July.

The grape-blossom midge is found in Chautauqua county, especially on early varieties of grapes. The adult midges emerge from the soil during the latter part of May and the first

* A reprint of Bulletin No. 331.

week in June. They mate soon after emergence and egg-laying begins. The females deposit the eggs in the blossom buds and soon perish. The eggs hatch in a few days and the larvæ feed on the pistil of the blossom bud. The work of the larvæ prevents the development of the buds and thus such injured buds do not produce any fruit. The feeding of the larvæ causes the buds to have an enlarged appearance and to become red in color. The larvæ feed about two weeks and then pass from the buds to the soil where they remain until the following spring. These larvæ form hibernating cocoons. Pupæ were found the first part of May. The pupal stage is at least three weeks in length. The use of a nicotine preparation as a spray was found to diminish the number of eggs laid.

The rose-chafer is a serious enemy of the grape when it is numerous. The adult beetles feed on the blossoms and are thus able to destroy the entire crop. The adults emerge from the soil about the 20th of June, almost always when the Concord grapes are beginning to blossom. Mating takes place much of the time the adults are feeding. The females burrow into the soil and deposit their eggs. They usually deposit them in sandy soil. The eggs hatch by the first week in August and the larvæ feed on the roots of grass until November when they burrow to a depth of about a foot and form larval chambers in which they pass the winter. In April they leave these chambers and resume feeding. During the latter part of May the larvæ form cells in which they change to pupæ. The pupal stage lasts from three to four weeks. Experiments were made with various insecticides to kill the rose-chafer and a mixture consisting of 10 pounds of arsenate of lead, 25 pounds of glucose and 100 gallons of water was found to be very effective in killing the insects. The net gain per acre over the unsprayed grapes was $61.84. Experiments proved that the numbers of the rose-chafer could be materially reduced by cultivating the soil when the insects are in the pupal stage.

The grape root-worm is the most serious insect pest of grapes in Chautauqua county. The larvæ feed on the roots of

the vine. The adults appear the latter part of June or the early part of July and feed on the foliage. The eggs are laid underneath the bark, principally on the canes. These hatch during the latter part of July and during August. The young larvæ pass to the grape roots and feed until fall. They then burrow deeper and form hibernating cells, which they leave in May and some of them will feed. The larvæ form cells several inches beneath the surface of the soil about June 1st or a little later, where they change to pupæ. The pupal stage lasts several weeks.

The most efficient method of controlling this insect is to spray the vines with an arsenical poison, preferably arsenate of lead, when the beetles are feeding. This is usually combined with bordeaux mixture. Experiments during 1910 appear to show that the use of a gallon of molasses, 6 pounds of arsenate of lead and 100 gallons of water is a very effective treatment.

The experiments with the grape leaf-hopper have shown that the nymphs are very easily killed by the use of a nicotine preparation, guaranteed to contain 2.7 per ct. nicotine, and diluted with 65 to 100 parts of water. Lime-sulphur solution as dilute as 1 gallon to 100 gallons of water proved very effective against the leaf-hopper nymphs but it generally caused much injury to grape foliage and the fruit.

INTRODUCTION.

The Chautauqua and Erie grape belt which is situated along the south shore of Lake Erie is the most important grape-producing section of New York State. This region at present is over sixty miles in length, extending from Erie, Pa., to Angola, N. Y., and varies from three to five miles in width.

For over thirty years the grape has been grown on a commercial scale in this section but the greatest development of the industry has been during the past twenty-five years. From 1885 to 1900 the industry was being developed and new vineyards were set out in great numbers. During this time little trouble was experienced

in growing this delicious fruit. From 1895 to 1900 the yields for this region were greatest. Since that time there has been a steady decrease in production. In 1900 there were about 30,000 acres in bearing vineyards in this region, of which 20,000 acres were in Chautauqua county. The canvass made by this Station in 1906–7 showed an increase to 30,000 acres of bearing vineyards in this county; and in subsequent years there have been additional plantings. The industry has also spread into Erie and Cattaraugus counties, and the acreage has been increased in Erie county, Pa., so that at the present date the estimated number of bearing vineyards in the Chautauqua grape region in New York is 35,000 acres and for the entire grape belt 50,000 acres. The area has almost doubled since 1900.

The figures below, taken from statistics gathered by the " Grape Belt,"* which have been carefully collected from year to year, show the yields from 1900 to 1910. The 1910 statistics are estimated in part, since all the data were not available when the bulletin went to press.

PRODUCTION BY YEARS OF CHAUTAUQUA AND ERIE GRAPE BELT.

Yield for	1900.........	8,000	carloads	Yield for	1906.........	5,465	carloads
"	1901.........	6,669	"	"	1907.........	5,186	"
"	1902.........	5,062	"	"	1908.........	4,232	"
"	1903.........	2,954	"	"	1909.........	7,561	"
"	1904.........	7,479	"	"	1910.........	5,070	"
"	1905.........	5,365	"				

A certain amount of fruit is used for the manufacture of wine and grape juice, which varies somewhat from year to year but does not show such a great fluctuation as to destroy the comparison between the yields for the different years.

It will be noted that although the acreage of the vineyards has been almost doubled since 1900 the production has at no time equalled the shipments of that year. This decline in the productivity of the vineyards was noted by the vineyardists who at length became alarmed at the situation and appealed to the State for aid. This appeal was answered with an appropriation by the legislature of the State whereby there was established a laboratory

* This newspaper is published in Dunkirk, and keeps in close touch with vineyard conditions.

and an experimental vineyard at Fredonia under the supervision of the New York Agricultural Experiment Station.

The decrease in the yield from year to year is not due to any one factor nor to the ravages of insect pests alone but to a number of causes which are being investigated, principally by the Departments of Horticulture, Plant Pathology, and Entomology.

BRIEF REVIEW OF THE ENTOMOLOGICAL WORK.

The entomological work was begun June 10, 1909.

During this season insect troubles were at rather low ebb. The experimental work with the rose-chafer was started in Mr. Bourne's vineyard at Westfield as were the experiments for the grape Fidia in Mr. Barnes' vineyard at Prospect Station. Besides the attempt to ascertain the distribution of the various grape insects in the county, and to develop more efficient methods of control much time was also spent in studying the life histories of many of the more destructive species. In addition to the five species discussed in this bulletin the following insects were also studied: The grape-berry moth (*Polychrosis viteana*), a blotch miner on grape (*Antispila isabella*), a serpentine miner on grape (*Phyllocnistis vitigenella*), the eight-spotted forester (*Alypia octomaculata*), the yellow bear (*Diacrisia virginica*), the diverse-lined moth (*Eustroma diversilineata*), the hog sphinx (*Darapsa myron*), the checkered grapevine sphinx (*Sphecodina abbotii*), the Pandorus sphinx (*Pholus pandorus*), the grape plume moth (*Oxyptilus periscelidactylus*), common tree cricket (*Oecanthus nigricornis*), the argus beetle (*Chelymorpha argus*), the red-headed systena (*Systena frontalis*), the vine chafer (*Pelidnota punctata*) and the grapevine colaspis (*Colaspis brunnea*).

During 1910 the entomological work was restricted to the life histories and experiments for the control of the five species discussed in this bulletin. All the field experiments were made in private vineyards located between Westfield and West Irving. About fifty acres of vineyards were used for experimental purposes. The author desires to extend his thanks to the following growers for the privilege of using their vineyards and for their

hearty cooperation while conducting the experiments: James Barnes, Prospect Station; Louis Bourne, Westfield; F. J. Clouse and H. L. Cumming, Fredonia; Charles Horton, Silver Creek; S. J. Lowell, Fredonia; M. J. Sackett and Charles Secord, Silver Creek.

These investigations have been made under the direction of Prof. P. J. Parrott, of this Station, who has been of great assistance to me, especially during the preparation of this bulletin, and I desire to extend to him my most hearty thanks for the same.

THE GRAPE FLEA-BEETLE.

Haltica chalybea Illiger.

ORDER **Coleoptera.** FAMILY **Chrysomelidæ.**

INTRODUCTION.

The grape flea-beetle, or "steely beetle," is a rather well-known pest, and it is usually the first insect to attack the vineyards in the spring. During the past two years, observations were made on the life history and the distribution of the species in Chautauqua county, and since it was learned that in certain years much damage has resulted from its depredations, experiments were made in several vineyards for the control of the pest.

The grape flea-beetle has been a serious pest in New York vineyards at various times for a number of years and is claimed to have caused much loss from time to time to grape growers. Slingerland (writing in 1898)[1] says "Our observations and correspondence would indicate that this flea-beetle has done more damage in our vineyards for several years past than all other insect foes combined." The reports of other entomologists show that the insect has been a cause of annoyance as well as positive injury in many vineyards throughout the State at various times during the past forty years.

ECONOMIC IMPORTANCE.

The amount of damage done to grapes by this insect varies from year to year. Some seasons it is found in thousands of acres of vineyards, especially those which are in close proximity to wood-

[1] Slingerland, M. V. Cornell Agr. Sta. Bul. 157. 1898.

land. During such severe infestations in the past, growers found it necessary to kill the beetles if they were to expect any fruit. Since the damage is done to the buds, the beetles can destroy a large part of the crop in a short time. Taking the Chautauqua grape-belt as a whole, it must be regarded as a minor pest, since its numbers fluctuate very much and, on the fore lands especially, such a large percentage of the soil is under cultivation that little damage results. However, in many acres of vineyard on the hill-sides it is common and does some damage every year. In years of serious infestations many acres of vines are badly injured and in some vineyards the crops are entirely destroyed. The "steely beetle," therefore, is a major pest to many grape growers.

HISTORY.

This flea-beetle was first described by Illiger[2] in 1807 from specimens from Pennsylvania and Georgia and was given the scientific name of *Graptodera chalybea.* Melsheimer in his catalogue of "Insects of Pennsylvania," lists it under the following names: No. 465 *Altica oleracea;* 424 *Chrysomela violacea;* 428 *C. cyanea;* and 441 *Altica cœrulea.* This was in 1806, a year before Illiger described it as a new species. The specific name *chalybea* means steel blue, which describes the usual color of the beetle. In 1824 Le Conte[3] described the insect under the name of *Galeruca janthina.* Thomas[4] (1834) again described the insect as *Chrysomela vitivora,* the specific name meaning vine feeder. Later studies by Harris appear to have convinced him that *C. vitivora* was a synonym for *Graptodera chalybea.* Harris also found that the insect belonged to the genus *Haltica,* where it has remained ever since. In 1834 Thomas gave the first description of the habits and life history of the insect. Harris has given a good description of the habits in "Insects Injurious to Vegetation" (1841, '42, '52, '62 Editions). Since 1841 there have appeared numerous references to the work, habits, life history and distribution of this species. The accounts given by Comstock,[5] Riley[6] and Slinger-

[2] Illiger. *Mag. für Insecten* **5**:115. 1807.
[3] Le Conte. *Ann. Lyc. Nat. Hist. N. Y.* **1**:173. 1824.
[4] Thomas. *Amer. Jour. Sci. and Arts* **26**:113. 1834.
[5] Comstock, J. H. Rept. U. S. Ent. pp. 213–216. 1880.
[6] Riley, C. V. *Amer. Nat.* **3**:152, 182–183. 1880.

land[7] have been the most important recent contributions to the literature of the insect.

ORIGIN AND DISTRIBUTION.

The steely-beetle is an American insect and is common to the eastern United States and Canada. It has been recorded from Maine to Florida and west as far as Colorado and New Mexico. The accompanying map (Fig 2.) illustrates this distribution of the species as known at present.

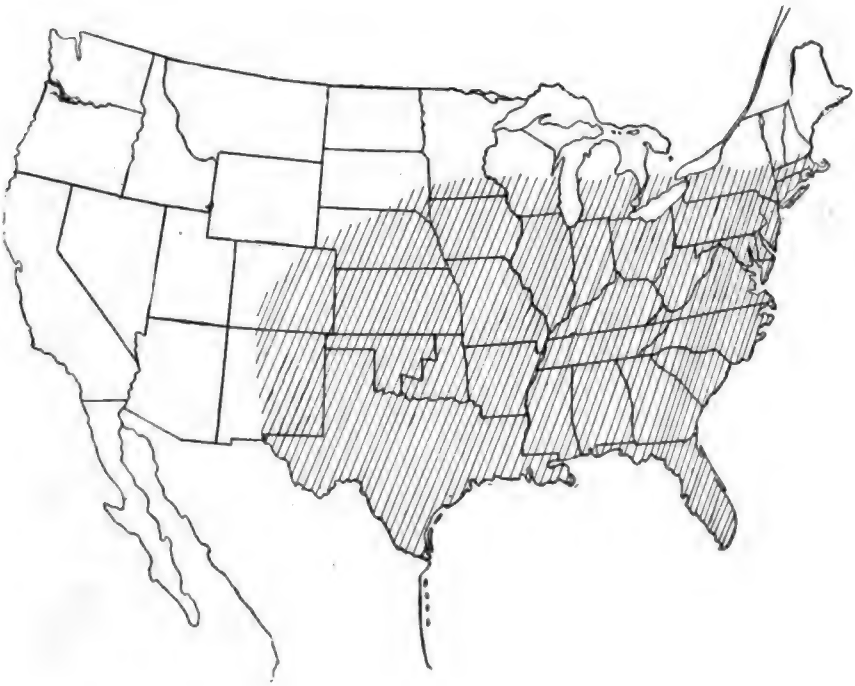

FIG. 2.— DISTRIBUTION OF THE GRAPE FLEA-BEETLE.

The insect is recorded in literature as of economic importance from the following states: Colorado (Gillette), Connecticut

[7] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 157. 1898.

(Thomas, Britton), Delaware (Norris), Florida (Horn, Neal, Schwarz), Georgia (Illiger, LeConte), Illinois (Hull), Indiana (Webster), Iowa (Kridelbaugh, Osborne), Maryland (Johnson, Chittenden), Massachusetts (Harris), Michigan (Horn, Pettit), Minnesota (Mendenhall, Lugger, Washburn), Missouri (Riley), Nebraska (Bruner, McMillan), New Jersey (Smith), New Mexico (Townsend), New York (Le Conte, Thomas, Emmons, Fitch, Lintner, Slingerland, Felt, Lowe, Parrott), North Carolina (McCarthy), Ohio (Kirkpatrick, Walsh, Webster, Kellicott, Burgess), Pennsylvania (Illiger, Melsheimer, Thomas, Riley), Texas (Horn), Vermont (Perkins), Ontario (Bethune, Saunders, Gott, Woolverton, Rennie, Lochhead). Slingerland says "it occurs throughout the eastern half of the United States from New England southward to southern Florida and westward through Canada and southern Minnesota, thence southward to eastern and southern Texas." Since Slingerland's publication (1898), Gillette[8] speaks of remedies for its control in Colorado. Townsend[9] had reported it from New Mexico in 1891. This would extend the distribution of the species to the eastern slope of the Rocky Mountains. This species is not found on the Pacific slope.

This flea-beetle is found in all the grape-growing sections of New York State and is usually localized, existing in largest numbers near places favorable for hibernation. In Chautauqua county the injury is almost always to be found in vineyards on the hillsides, since here there is more woodland which offers protection for passing the winter. It is very seldom that we hear of injuries on the lower land extending from the foot of the hills to the shore of Lake Erie.

The attacks of the beetles are rather desultory. Often the insects are scarcely noticed for a number of years when they suddenly develop in injurious numbers and do much damage for a season or two, then almost completely disappear again. This phenomenon is common to all insects and is influenced by weather conditions, parasites, predaceous enemies and the influence of man (such as clearing of waste land or better cultural methods). It is

[8] Gillette, C. P. Col. Agr. Exp. Sta. Bul. 71, p. 18. 1898.
[9] Townsend, C. H. T. N. Mex. Agr. Exp. Sta. Bul. 3, pp. 6–7. 1891.

a common experience to find the beetles numerous in a restricted area from year to year, and while they may destroy many buds annually in such locations they do not migrate very far. The distance they migrate appears to be influenced largely by the food supply. Usually an area of a few acres of vines will furnish food enough for their sharpened appetites. However, when their numbers are greatly increased they will infest an area of several hundred acres.

FOOD PLANTS.

The various species of wild grape are without doubt the natural food plants of the flea-beetle. Other food plants have been recorded as follows: plum (Fitch, Britton, MacMillan), apple (MacMillan, Lugger), quince (MacMillan), blue water beech (Schwarz), elm (Glover, Packard), Virginia creeper, *Psedera quinquefolia* (Saunders). The beetles attack the swelling buds as well as the leaves of these plants and may cause serious injury to fruit trees. In Chautauqua county several species of wild grapes are common but *Vitis bicolor* is most abundant in thickets on the hillsides. The beetles feed on these wild grapes especially when remote from a vineyard. On the other hand such thickets have become centers of distribution from which the beetles migrate into the neighboring vineyards.

CHARACTER AND EXTENT OF INJURY.

The flea-beetle attacks the vine at three different times during the year; viz., during June and July as a larva, as a beetle during August and September after emerging from the pupal stage, and during April, May and June after hibernating. The larvæ eat irregular holes into the leaves, feeding only on the softer tissues. (Plate XXXIX, fig. 4.) The veins remaining soon turn brown which gives the leaves a striking appearance that can be seen at some distance. The beetles, after emerging from the pupal stage, feed on the leaves, making irregular areas similar to those caused by the larvæ. The greatest damage to the grapes is done in the spring when the beetles emerge from their winter quarters, for they feed on the swelling buds of the grape, eating holes into

them. (Plate XXXVII, figs. 2 and 3.) Such buds never develop; so that the crop of grapes that normally would have issued from these places is literally "nipped in the bud." When the uninjured buds open the beetles feed on the leaves, eating irregular openings in them. (Plate XXXVII, fig. 1.) The injury is often so severe that many vines will have every bud destroyed. Although the vine may put forth leaves it will not produce fruit the same season, causing a monetary loss to the owner. The amount of damage the beetles can do in the spring is tremendous and is often done before the unsuspecting owner sees the active creatures at work. The injuries to plum, apple, peach and quince that have been reported were caused by the insects eating holes into the swelling buds or feeding extensively on the leaves. MacMillan claims that they have injured grafts on such trees by feeding on the buds. It is difficult to estimate the amount of injury these creatures inflict upon grapes in Chautauqua county and other grape-growing sections of the State, but accounts in the literature of the species indicate heavy losses some years from the insect. Reports from many grape growers and our observations indicate losses sometimes to the extent of several thousand dollars a year in Chautauqua county alone.

DESCRIPTION OF THE INSECT.

Egg.— The eggs of the grape flea-beetle are small, orange or saffron-colored bodies of a cylindrical shape, having the ends almost hemispherical. The thickness is about two-fifths their length. (Plate XXXVIII, figs. 1 anl 2.) They vary considerably in size. Forty eggs were measured, part of the number having been collected in the vineyards, part were taken from the cages, and the average length of an egg was found to be 1.03 mm. (.04 inch) and the average width .4 mm. (.016 inch). The shortest egg was .93 mm. (.037 inch) while the largest egg was 1.14 mm. (.045) inch. The width of the eggs varied from .33 mm. to .46 mm. (.013 inch to .018 inch.) The coating of the egg is of a roughened appearance due to small pits found over the entire sur-

face. This coating can be removed and the inner shell of the egg is seen as an almost transparent membranous covering which has a light yellow color. These two layers are often seen on eggs that have had the outer covering broken in an attempt to raise the loose bark of the canes under which the females place many of the eggs.

Larva.— The larvæ when first hatched are dark brown in appearance. The head is rounded, the eyes prominent, diameter of head .35 mm. (.014 inch), which equals the diameter of the body. The body is .9 mm. (.035 inch) in length, tapering gradually to the anal segment and covered with many long hairs. The later stages of the larva (Plate XXXIX, fig. 1) are lighter in appearance, each segment of the body being covered with darker areas which surround one or more tubercles bearing short setæ; the head dark with a number of hairs; the dorsal portion of the prothorax with a large dark area; three smaller, dark areas on the ventral side; the meso- and metathorax each with a prominent dark spot on the side and smaller dark areas both above and below it. The tarsi are shining black. Each segment of the abdomen has six tubercles on a side above the spiracle. These tubercles are surmounted by a single hair and surrounded with a dark area. The dark areas of the tubercles near the median line join with those opposite, thus giving the appearance of elongated, dark stripes. Below the spiracle there are two dark areas each of which is the combined areas of two tubercles bearing setæ; below there is a single tubercle and seta and just above the proleg is an elongated area bearing two setæ. The length of the fully developed larva is between 7 and 9 mm. (about .3 inch.)

Pupa.— Body yellow, 4 mm. to 6 mm. (.16 inch to .24 inch) in length. Wings and legs show almost white. Two setæ on vertex and two on occiput of head. Two spines on prothorax rather widely separated, four spines on the mesothorax with the same number on metathorax. Abdomen with three rows of setæ on each side above the very distinct stigmata; setæ of the last two segments prominent. Anal segment with two hook-like processes

extending up and backward. The ends of the femora have two setæ but not the hook-like process as does the pupa of Fidia.

Adult.— The beetles are from 4 to 5 mm. (.16 to .2 inch) in length and of a shining steel-blue color. (Plate XXXIX, fig. 2.) They have a neat, trim appearance, although the body of the insect is rather stout. The femora of the hind legs are very much thickened, which fit the insects for jumping. These insects are very agile especially on warm, sunny days. This species belongs to the family Chrysomelidæ to which family belong the Colorado potato-beetle, the grape root-worm and many other destructive insects.

SEASONAL HISTORY.

Emergence and hibernation.— The adult beetles appear the latter part of July and feed in the vineyards but do little damage owing to the large amount of foliage on the grape. It is very probable that they also feed on other food plants at this time. With the approach of cold weather these insects seek shelter to hibernate. They crawl into all sorts of protected places but prefer the woodland and waste spots near the vineyards. Here they hide under leaves and among rubbish, beneath the bark of trees or grape vines, under sticks, stones, in fact beneath almost anything that will furnish them shelter.

During the warm days of early spring when the chickweed (*Stellaria media*) is first beginning to bloom in the vineyards, when the yellow adder's-tongue (*Erythronium americanum*) is sending forth its yellow chalices, and when the ground ivy, otherwise known as gill-over-the-ground (*Nepeta hederacea*) is twining over the banks with its earliest purple flowers, we can expect to see the trim, steel-blue beetles moving about on the grape vines seeking, after their long winter fast, to satisfy their hunger upon the swelling buds. Another plant that may be showing its first blossoms in sheltered places at this time is the common dandelion (*Taraxacum officinale*).

The activity of the beetles is influenced very much by the condition of the weather. On bright, sunny days the beetles are quite

active and feed voraciously on the swelling buds, and at such times they are hard to catch owing to their agility. A visit to these same vineyards a day or so later, when a cutting wind is coming from the north, especially if it is cloudy, will not reveal many of the steely beetles. They seek shelter under stones, brush, bark or any other place that will protect them from the cold. In the breeding cages where the wind cannot reach them they become inactive and will remain in hiding during cold, cloudy days in spring, coming out only occasionally to get food. The beetles are most active during the warmer part of the day and especially when the sun is shining.

The length of the adult or beetle stage is between ten and eleven months, since they emerge from the pupal stage during the last week in July and the first week in August, and are found in the vineyard until the middle of June the following year, some adults being found as late as July 1.

Feeding habits.— On emerging from hibernating quarters the beetles proceed to eat into buds from the side and make circular holes which usually extend into the center of the buds (Plate XXXVII, fig. 2). Sometimes they eat entirely through the buds (Plate XXXVII, fig. 3). In either case the bud is destroyed and with it the crop of grapes that would have grown from its shoot. Where the beetles are numerous they often destroy nearly every bud that the grower has left on the canes. This damage is usually worst near thickets or waste sections that have afforded hibernating places for them. When the leaves appear they feed on them, eating small holes. (Plate XXXVII, fig. 1.) In feeding, the beetles appear to show no preference as they subsist on the buds that are low down as well as those higher on the vines.

Mating.—After feeding for a short time mating takes place, which continues for several weeks. This again is dependent on the weather. In the cages, the time varied from one day to two weeks and a half after the first observed mating. The act of copulation of two beetles was watched and it was found to occupy the space of two hours and fifteen minutes. In the cages one pair

of beetles were observed mating at five different times and there is every reason to believe this took place more often. In recording the number of times of copulation in the cages it is impossible to record each act unless an observer should be with the cages continually from early spring until the beetles died. As that was impracticable, the object of making even only a partial record is merely to show that the period of copulation extends over considerable time which may be somewhat longer than recorded above; and that the act is repeated with the same pair, the repetitions being certainly more frequent than was observed, owing to the necessity of being away from the cages much of the time.

Egg deposition.—In a few days after mating the female beetles begin to lay eggs. The eggs may be placed in a number of situations. The most usual places are underneath the scales surrounding the buds (Figs. 1 and 2, plate XXXVIII) and underneath the loose bark of the canes (Plate XXXIX, fig. 3). Several times they were found deposited on the upper surface of the leaf, but this is rather uncommon. The eggs are also placed on and around the buds and on the rough back where they appear to have less protection than when placed in their usual position. Sometimes the crevices of the bark are filled so full that the eggs are easily jarred loose and fall to the ground. Generally the female fastens the eggs with a mucilaginous material, so that attempts to remove them with a needle result in the rupturing of the outer covering.

The data regarding egg-laying were secured by placing copulating couples in cages where their habits were watched.

Cage 9ad was established on April 14 when the beetles were captured in the vineyard. The three copulating couples were placed together to determine the average number of eggs. The other cages containing a single pair of beetles were taken from a stock cage. The stock cage was watched carefully for copulating couples from April 14 to April 28 but the spell of unusually cold weather between these two dates caused the beetles to keep in hiding under stones and other objects in the bottom of the cage. With the warmer weather of April 28th came a renewal of activity and

cages 9af, 9al, 9am, 9an were started. The remaining cages were established May 2. It was also desired to learn whether better results in egg numbers could be obtained by placing several pairs together than by placing a single pair in each cage. This is shown in the table of results in cage 9ad. (Table I, pages 434–435.)

Records in Table I may be summarized as follows:

TABLE I.— EGG-LAYING RECORDS OF THE GRAPE

DATE.	Cage 9ae.	Cage 9ak.	Cage 9al.	Cage 9am.	Cage 9an.
	Eggs.	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*
April 14	*	....	....	....	.....
28	....	*	*	*	*
29	....	*	....	2	*
30	....	* 3	†	*	*
May 2	2	* 5	3	* 3	5
3	9	13	17	8	8
4	....	5	....	2	2
6	....	....	....	3	.....
7	6	*	....	2	2
8	....	3	6	7	2
9	....	....	....	....	.....
10	9	....	11	† 4	.....
11	....	....	....	....	.....
13	¶	4	....	8	†
15	....	2	¶	6	¶ 1
18	†	....	....	¶	.....
20	....	....	....	....	.....
21	....	....	....	....	.....
24	....	....	....	....	.....
26	....	....	....	....	.....
29	....	....	....	....	.....
31	....	....	....	....	.....
June 2	....	* *	....	....	.....
3	....	....	....	....	.....
6	....	....	....	....	.....
8	....	....	....	....	.....
12	....	....	....	....	.....
15	....	....	....	....	.....
18	....	....	....	....	.....
20	....	....	....	....	.....
SUMMARIES.					
Total eggs	26	35	35	45	20
Number of ovipositions	4	7	4	10	6
Average number of eggs per oviposition	6.5	5	8.7	4.5	3.3
Maximum number for one oviposition	9	13	17	8	8
Minimum number for one oviposition	2	2	3	2	1
Length of egg-laying period (days)	9	16	9	17	14
Maximum number of days between ovipositions	4	5	5	3	7
Average number of days between ovipositions	2.6	2.6	2.6	[illegible].8	2.6
Minimum number of days between ovipositions	1	1	1	1	1
Number of copuations observed	1	5	1	3	3
Length of copulating period (days)	1	10	1	5	3

* Copulating. † Male dead.

VINE FLEA-BEETLE AT FREDONIA, N. Y., IN 1910.

Cage 9aq.	Cage 9ar.	Cage 9as.	Cage 9au.	Cage 9av.	Cage 9aw.	Cage 9ax.	Cage 9ay.	Cage 9az.	Cage 9ba.	Cage 9bb.	Cage 9bc.
Eggs.	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*	*Eggs.*
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
*	*	*	*	*	*	*	*	*	*	*	*
3	*	....	* 1	....	* 3	1	7	7	2	2	....
*	2	....	*	*	1	*	* 1	*	* 1	....	....
*	....	....	....	....	....	....	....	....	....	*	*
3	*	5	....	....	1	....	*	5	* 1	....	*
....	* 5	3	9	1	9	4	7	6	3	8	12
* 6	....	....	....	....	....	....	*	*	....	*	....
....	....	6	1	4	6	1	* 6	4	2	2	3
9	17	....	....	....	....	....	....	....	....	....	....
5	2	10	† 4	....	** 8	†	5	1	3	¶	....
1	10	....	7	....	....	3	7	11	1	....	† 2
†	10	3	¶	**	....	....	5	† 3	†	....	....
¶ 2	¶	**	....	....	....	5	....	6	....	†	1
....	†	....	....	....	....	....	17	....	....	....	1
....	....	....	....	....	....	10	5	2	1	....	....
....	....	....	....	....	....	4	9	....	....	....	....
....	....	....	....	....	....	....	4	....	3	....	2
....	....	....	....	....	....	1	5	5	....	....	....
....	....	....	....	....	....	8	....	....	....	....	....
....	....	....	....	....	....	3	....	....	....	....	....
....	....	....	....	....	....	1	1	....	....	....	....
....	....	....	....	....	....	5	4	....	....	....	....
....	....	....	....	....	....	10	16	1	....	....	¶
....	....	....	....	....	....	¶	4	....	¶	....	....
....	....	....	....	....	....	....	....	¶	....	....	....
....	....	....	....	....	....	....	**	....	....	....	....
29	46	27	22	5	28	56	103	51	17	12	21
7	6	5	5	2	6	13	16	11	9	3	6
4.1	7.6	5.4	4.4	2.5	4.6	4.3	6.4	4.6	1.9	4	3.5
9	17	10	9	4	9	10	17	11	3	8	12
1	2	3	1	1	1	1	1	1	1	2	1
18	15	12	13	3	11	41	44	41	27	8	22
5	4	5	5	2	3	5	7	13	9	5	8
2.8	2.8	2.8	3	3	2	3.3	2.9	4	3.3	4	4.2
2	2	1	2	2	1	1	1	1	1	2	1
4	4	1	3	2	2	2	5	3	3	3	3
8	7	1	3	3	2	3	9	8	6	8	6

¶ Female dead. ** Male and female dead.

TABLE II.—SUMMARIZED DATA OF MATING AND EGG-LAYING OF CONFINED GRAPE FLEA-BEETLES.

	Maximum	Minimum	Average.
Times beetles were observed mating	5	1	3
Length of mating period (days)	10	1	5
Total eggs laid by one female	103	5	34
Number of ovipositions by one female	13	2	7
Number of eggs at one oviposition	17	1	4.8
Length of egg laying period (days) of one female	44	3	18.8
Length of egg laying period (days) of all females	48	....	....
Days between oviposition of individual females	13	1	2.9

TABLE III.—RESULTS OF EGG STUDIES ON CAGE 9AD CONTAINING 3 COPULATING COUPLES OF GRAPE FLEA-BEETLES.

Date.	Eggs.	Copulations.	Date.	Eggs.	Copulations.
April 14 (cage started).			May 24	16	Copulating.
April 14	0	Copulating.	26	7	
28	3		29	3	
30	6		31	5	
May 2	8	Copulating.	June 2	5	Copulating.
3	18		6	11	
4	8	Copulating.	8	1	Copulating.
5	0	"	12	7	
6	0	"	15	8	
7	1	"	18	8	
8	17	"	23	1	1 beetle dead.
9	6	"	25	0	3 " "
10	12	"	July 6	0	2 " "
13	16	"	Total	214 eggs	
15	8				
18	12		Average per female	71.3 eggs	
20	12	Copulating.			
21	15	"			

A comparison of all these cages will show that the period of copulation and of egg-laying was longest in cage 9ad. In the other cages May 10th marked the last of the copulating period and a little later there was a high mortality of the males, almost all being dead before the first of June, the majority by the middle of May. The females, with four exceptions, were dead before the middle of June. In cage 9ad on the other hand (all cages were treated exactly alike as regards moisture and food) the period of copulation extended to June 8, a period of 55 days; and the egg-laying extended to June 23, a period of 56 days — almost a week longer than any other cage. If we compare the average number of eggs of cage 9ad with the average number of eggs from the three cages having the highest number of eggs (9ay, 9az, and 9ax), we find a total number of 210 eggs or an average of 70 eggs. It therefore appears that in future egg studies of these beetles several cages containing a number of paired couples in each should be under observation at the same time and under the same conditions as the cages having a single paired couple in each.

A peculiar condition was met with in cage 9at. This cage was started May 2 with a copulating couple. Copulation was continued until May 10 daily but no eggs were laid by the female. The male died May 13 and the female May 20. This sterility of the female was unusual, we believe, and this cage was not included with the others in the tabulated results.

An egg was found on a cane in the vineyards as early as April 14th, but two weeks of cold weather put a stop to the movements of the beetles, so that the oviposition was not very active until about May 1st. From this date until June 25th egg-laying was in progress in the cages. On June 8th a trip was made to the infested vineyard, and as a number of beetles were present on the vines some were taken to the laboratory and placed in cages to determine the latest date of egg deposition. The latest date was found to be June 12th for these beetles, while a female in one of the regular cages (9ad) deposited her last eggs on June 23d. We believe that the later date corresponds very closely to

the date of the last oviposition in the vineyards, since visits to the vineyard shortly afterward showed very few beetles on the vines. We conclude that the egg-laying period of the grape flea-beetle may extend over a period of more than two months but that the greatest number of eggs are laid during a period of a month and a half, which in normal years would be from the later part of April to the early part of June.

Egg.— The length of the egg stage depends to a large extent on weather conditions. Eggs were deposited in the vineyards and in the cages from April 14th to June 23d. The earliest larvæ hatched in the cages June 20th, and were hatching in the vineyards about the same date; for a visit to the infested vineyards June 24th showed a large number of larvæ feeding on the leaves, although many of the eggs on the vines were not hatched.

June 28th Mr. Wayne B. Stowe, living at Westfield, sent to the laboratory a number of larvæ which he had found on his vines, and on the same date Mr. C. D. Darling, of Fredonia, brought a number of larvæ which he had taken on grapes at Portland.

The eggs were found to hatch as late as July 4th, which gives an egg stage from twenty to sixty days, depending on the time the eggs were deposited, since eggs deposited in April hatched only two weeks earlier than those deposited in June.

A visit to a number of infested vineyards July 6th revealed the fact that there were no eggs remaining unhatched on the vines.

Larva.— The larvæ began hatching June 20th in the cages, and perhaps the first larvæ made their appearance in the vineyards about this date, for many larvæ were found in the vineyards on June 24th.

The larvæ feed on the upper surface of the leaves in which they eat irregular areas. They do not eat entirely through the tissue of the Concord but there remains a network of veins undisturbed. The veins soon turn brown and thus the injured area, which varies in size, has a brown appearance which can be seen at a distance. (Plate XXXVIII, fig. 3.) From observations in the infested vineyards it was learned that the larval stage lasts be-

tween two and three weeks, extending normally from the last week in June until nearly the middle of July. These larvæ upon reaching full growth drop to the ground, and after digging into the soil for a few inches form cells in which they change to the pupal stage.

Pupal stage.— Studies on the pupal stage were made during 1909 (the egg studies were made in 1910). Twenty larvæ were placed in a cage July 6th. These were nearly full grown, and after feeding went into the soil in the bottom of the cage July 11th. Here they began to form pupal cells by rolling themselves about. Several of the larvæ formed cells near the sides of the cage, so they were observed and their transformation recorded. The larvæ transformed to pupæ July 16th, thus remaining five days in the cells before changing to pupæ. The pupal cells are between two and five inches below the surface of the soil in the vineyards.

The pupæ do not remain entirely quiet but move their abdomens up and down much of the time. Four beetles emerged July 27th. The pupal stage in this instance was eleven days. The other pupæ died before transforming.

SUMMARY OF LIFE HISTORY.

The eggs are laid during the months of April, May and June on the canes of the grape, and hatch during the latter part of June or early part of July. The length of the egg stage varies from two months for the earlier-laid eggs to three weeks for the eggs laid later in the season. The time of hatching depends on the temperature but extends from the latter part of June into July, according to the season. The larvæ upon hatching begin to feed on the foliage and in about three weeks attain their full growth. They then drop to the ground and burrow to a depth of several inches, where they form cells by twisting their bodies about. The larvæ remain in these cells several days before changing to pupæ. The pupal stage occupies from ten days to two weeks. The adults remain in the cells about a day before emerging.

Upon emergence the beetles feed on the grape leaves but they do not cause much injury, owing to the mass of foliage the grapes have at this time. With the coming of cold weather the beetles seek places suitable for hibernation. Dry leaves and rubbish in woodland or waste land are favorite places for them to hibernate. During the month of April, when the weather becomes warm, these beetles come from their hibernating places and feed upon the swelling buds of the grape. Mating soon begins and occurs at intervals for a period of over a month. From April to June the sexes may be found in copulation, especially during the warmer days. Egg-laying begins the latter part of April and extends to the middle of June. The majority of beetles die during June, but individuals may be found in July. The adult stage lasts between ten and eleven months.

EXPERIMENTS WITH SPRAYING.

There has been some doubt expressed regarding the efficiency of an early spraying with arsenicals because the poisons act slowly. Such spraying was, therefore, considered worthy of experimentation and, accordingly, an effort was made in April to secure a badly infested vineyard where such trials could be made.

Among the vineyards of Mr. F. J. Clouse, about four miles south of Fredonia and near the top of the escarpment which is the southern limit of the grape belt, was found a small patch of vines, nearly an acre in extent, lying between woodland to the east and a thicket on the west, and having many of the trim little blue-coats feedings on the buds. These vines were divided into plats and sprayed (April 15) with various strengths of arsenate of lead in water. A hand sprayer was used, which gave a rather low pressure, but the buds were carefully covered with the poison. Other plats were left untreated. Several trips were made to this vineyard during the next two weeks, and it was noted that fewer buds were injured and a smaller number of beetles were found on the sprayed vines. The egg-laying also was reduced on these vines. The injured buds on a large number of vines on all the plats were counted and the number on sprayed and unsprayed vines did not show as great difference as they

should to make the spraying of economic importance. Laboratory experiments were then made to learn the effectiveness of several insecticides. The first experiment was started April 25th. Ten beetles were placed in a cage and fed grape buds sprayed with arsenate of lead at the rate of three pounds to fifty gallons of water. Two beetles died April 28th — seventy-two hours after spraying, three on April 30th — five days after spraying, and three more May 2d — seven days after spraying. The two remaining beetles were fed sprayed buds until May 4th — nine days after spraying — and as they had not died by this time were fed unsprayed leaves and buds. One beetle died May 10th, the other May 20th. Both were apparently natural deaths since beetles in other cages died at various times during May. This experiment demonstrated that arsenate of lead acts very slowly on the beetles and also shows that beetles may feed for a short time on sprayed buds, and if they find unsprayed buds on which to feed the arsenic does not injure them.

During the summer of 1907 J. Capus and J. Feytand made a number of experiments in Gironde, France, for the control of the European grape-berry moth in which it was learned that barium chloride (2 per ct. solution) and molasses was found to be very effective.* Knowing of these experiments it was decided to try barium chloride for the control of the steely beetle, and having on hand some confectioner's glucose this was used instead of molasses. The glucose was used as a four per ct. solution in water. At the same time arsenate of lead was used with and without glucose, especially as a check on the results of the barium chloride and glucose.

The average length of time required for the different substances to kill the beetles was as follows:

Barium chloride, glucose and water	168 hours
Arsenate of lead, 8 pounds in 100 gallons of water	36 hours
Arsenate of lead, 8 pounds, and glucose, 25 pounds, in 100 gallons of water	4 hours
Arsenate of lead, 4 pounds, with or without glucose, in 100 gallons of water	111 hours

* *Prog. Agr. et. Vit.* (Ed. l'Est-Centre), **29**, No. 29:77–87. 1908. Review in *Exp. Sta. Record* **21**, No. 3:254.)

Thus, while trying the value of barium chloride we learned that arsenate of lead and molasses is a most efficient remedy for this flea-beetle. This mixture was not tried in the vineyard for the flea-beetle, but was tried in June with very good results as a spray for the rose-chafer (p. 475).

It appears from cage and field experiments that the grape flea-beetle is not easily controlled by the use of arsenate of lead alone but that by adding either molasses or glucose to the poison the beetles will be held in check.

Further experiments are necessary to give us more facts regarding the use of this insecticide. One factor that must be decided by field experiments is the length of time this material is effective and especially the effect of rain on the sprayed material. If, on the other hand, all the beetles are in the vineyard within a short time after spraying and the majority are killed by the mixture, there is no need of worrying about the effect of rain, etc., on the material; at least so far as the flea-beetle is concerned. The results secured from the use of molasses and arsenate of lead on Fidia (p. 496) indicate that a small amount of molasses may be used instead of the twenty-five pounds of glucose.

CONTROL MEASURES.

Various methods for controlling this insect have been recommended, among which the following are usually considered of practical value: Clean culture, jarring the beetles into vessels having a shallow layer of kerosene in the bottom, jarring the insects upon frames covered with muslin saturated with kerosene, hand picking and spraying.

Clean culture.— As has been mentioned before, the vineyards near woodland or waste land are much more liable to injury from these insects than the vineyards surrounded by cultivated land. This fact shows the value of clean culture where it can be applied. By this term is not meant here keeping the vineyard. bare and free from all vegetation, but rather the clearing of waste land or woodland, thus destroying all places where the beetles can pass

the winter. However, this practice can be applied in only a few isolated cases. If a vineyard adjoins a portion of woodland, it would be extreme folly for the owner of the vineyard to destroy valuable young timber to save his vineyard from flea-beetles. Again, much of the waste land is so situated as to be worthless except for timber. It is very evident that clean culture cannot be recommended as a practicable method for combating the insect in most of the infested vineyards in Chautauqua county.

Jarring the beetles into vessels holding kerosene.— This is a common practice when the beetles are numerous in the vineyards. Boys and girls are usually hired to go from vine to vine and knock the beetles into vessels which they carry. This method has been found practicable, as the cost of saving the crop is not excessive. It is a laborious operation, and many vineyardists find it more convenient to use the following method:

Jarring the beetles on covered frames saturated with kerosene.— A frame is made of narrow strips or roofing lath. It is rectangular in shape, about six feet long and three feet wide, covered with muslin and kept saturated with kerosene. The frame is carried by two boys and is placed under the infested vine, which is jarred. The beetles have the habit of dropping to the ground, which permits them to be caught on the sheet and quickly destroyed by the kerosene. This is a more expeditious method than the preceding and has been used effectively by several growers during periods of severe infestation. It certainly is a more practicable operation than hand picking. There are vineyards so situated that this method would be less expensive than spraying. That it would be better in most vineyards is doubtful.

Hand-picking.— This is really no method of control and is dismissed without further comment.

Spraying.— This has been mentioned in most of the recent literature as an effective method of controlling the steely beetle. Spraying can be used to combat this insect at two periods of its life: during the spring, when the adults are feeding on the buds, and in June and July, when the larvæ are feeding on the leaves.

If it is necessary to spray in the spring for the adults, it should be done as soon as the beetles appear in the vineyards if the greatest good is to be secured. At least eight pounds of arsenate of lead should be used to each 100 gallons of water, to which should be added a gallon of molasses or twenty-five pounds of glucose. It is believed that the glucose will remain on the vines longer than molasses since it is not so soluble in water, thus not suffering so much from washings by rains.

The method of applying the spray will vary with the extent of infested vineyards. Where the infestation is confined to a corner of the vineyard, spraying may be done with a knapsack sprayer, but on larger areas a barrel sprayer on a wagon fitted with about fifteen feet of hose will be found very efficient. One of the regular vineyard sprayers may be used.

If the grape flea-beetle is an annual pest in a vineyard, the most efficient work can be done when the larvæ are feeding on the leaves. This occurs during the later part of June and the early part of July. Spraying with the arsenate of lead at this time will kill the larvæ and thus destroy the beetles that would feed on the buds the following spring. Since these larvæ appear about the same time as the adults of the grape root-worm the same spraying will suffice for both insects. In fact, in vineyards where spraying is a usual practice these flea-beetles seldom cause injury.

THE GRAPE-BLOSSOM MIDGE.

Contarinia johnsoni Sling.

ORDER **Diptera.** FAMILY **Cecidomyiidæ.**

INTRODUCTION.

During the past six years the grape-blossom midge has been found in the Chautauqua grape belt where it has done considerable damage in certain vineyards, especially on the earlier varieties of the grape. This damage has been very marked in the vine-

yard of Mr. H. L. Cumming at Fredonia where several acres of Moore Early and Worden grapes were badly infested in 1908 and 1909. This damage was less severe in 1910. The insect has been reported on Champion and Massassoit grapes and is found in varying numbers on Concords, but the infestations never have been very serious. Most of the studies of the biology of this species and all the experiments for the control of the same were made in this vineyard.

ECONOMIC IMPORTANCE.

This insect has been found most injurious to the early varieties of grapes, but only occasionally have its attacks assumed serious proportions. In the vineyard of Mr. Cumming in 1908 and 1909 between 50 and 60 per ct. of the blossom buds were infested, but in 1910 less than 10 per ct. of them. The average Concord vine yard showing the presence of the midge had about 1 per ct. of the buds affected in 1908 and 1909. Since the Concord is the principal variety of grape grown in Chautauqua county, the present indications are that this insect will not be a serious pest to the grape industry. However, the facts that a similar insect is often injurious to grapes in Europe, and that the midge seriously threatens the production of early varieties in Chautauqua county make the insect worthy of investigation and experimentation.

HISTORY.

The grape-blossom midge was first found as a larva near Westfield, N. Y., by Mr. Fred Johnson[1] who at that time was engaged in entomological work with the late Prof. Slingerland. The latter recognized it as one of the Cecidomyiidae and suggested that if it were found to be a new species it be given the specific name *johnsoni*. The larvæ were found infesting the blossom buds of the grape, but all attempts to rear the adult were failures until the spring of 1909 when Dr. E. P. Felt, State Entomologist of New York, reared the adult from a cage in which the larvæ had been

[1] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 224, pp. 71–73. 1904.

placed the year before.* He recognized that it belonged to the genus Contarinia and accordingly has given it the scientific name of *Contarinia johnsoni* Sling. Dr. Felt[2] says: "*Contarinia viticola* Rübs., which future study may show to be identical with the species attacking grape blossoms in the Chautauqua region, has been recorded as injurious to grape blossoms in Europe by Rübsaamen,[3] a noted authority upon this group."

ORIGIN AND DISTRIBUTION.

The origin of this insect in America is at present unknown. Should it prove to be identical with the grape-blossom midge of Europe it might be presumed that this insect is an introduced species from Europe, while the opposite belief might be entertained; namely, that it is a species native to America and has been introduced into Europe. More observations are necessary before we can be in a position to affirm that either theory is true.

The exact distribution of this species is not known. It is present in all parts of the Chautauqua and Erie grape regions, but has never been reported from any other section. It is hoped that the systematists in this group will be able to decide definitely the question of identity of the two species, as then the collecting of specimens from various regions will assist in defining the distribution of the species, especially regarding its presence or absence in Europe.

FOOD PLANTS.

The several varieties of American grapes have been noted as food plants of the larval stage of the insect. However, the early

* In 1910, both Mr. Fred Johnson and the author, working independently, secured large numbers of adults. Mr. Johnson placed many infested blossom buds on the ground near grape vines in 1909. The larvæ left the buds and passed into the ground. By covering the ground with a framework covered with black paper the insects were trapped and were secured by placing glass tubes in holes bored through the frame, the insects being attracted to the light. The author's method was to cover a portion of the ground under vines in the infested vineyard with a cloth-covered trap-case having no bottom. These cages were six feet long, three feet wide and a foot and a half high. They were placed under vines of Worden and Moore Early grapes May 16 and 17, 1910.

[2] Felt, E. P. N. Y. State Mus. Bul. 134, pp. 15–19. 1909.

[3] Rubsaamen, E. H. *Ztschr. Wiss. Insektenbiol.* 2:194–198. 1906.

Rubsaamen, E. H. Die Wichtigsten deutschen Reben-Schadlinge und Reben-Nutzlinge, pp. 74–76. 1909.

varieties of grapes are most liable to attack owing to the fact that the blossoms of the early varieties are farther advanced than those of the late varieties at the time the adult midges are depositing their eggs. A careful examination of the blossom-buds the later part of May will show that the more advanced buds have a small opening at the apex, caused by the slight spreading of the petals as shown in Fig. 3. A comparison of buds of Concord and buds of earlier varieties such as the Moore Early and Worden will show that whereas in the Concord there are very few buds so far advanced, in the earlier varieties most of the buds have this opening. The fleshy ovipositor of the female is not capable of being forced through plant tissue, but is inserted in such slightly open buds and the eggs deposited. This accounts for the greater infestation on early varieties.

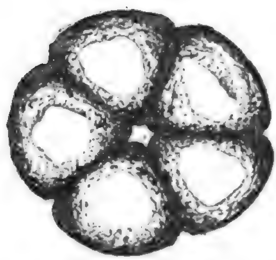

FIG. 3.—APEX OF GRAPE BLOSSOM-BUD SHOWING SPREADING OF PETALS. (Much enlarged.)

CHARACTER AND EXTENT OF INJURY.

The injury to the grape is done by the larvæ. An examination of grape-blossom clusters, especially early varieties about the first of June, will show certain blossom buds larger than the others and usually with a distinct red color, although the buds may show a yellow color when first infested. This red color is more prominent at the apex and along the sutures but is usually very pronounced over the entire bud. Such buds may be swollen until they are three times the size of the green, healthy buds on the same cluster. (Plate XL, fig. 1.) On opening one of these buds it is found to be filled with a watery liquid and a number of white, almost transparent, maggots living within. (Plate XL, fig. 2.) The number of maggots varies from several to as many as seventy in a single bud, but the average during a year of serious infestation, as in 1909, is about twenty-five. In 1910, the infestation was slight and the buds did not average more than ten larvæ. The injured blos-

som buds did not open but the parts dried and finally dropped off. The effect of this is shown in Plate XL, fig. 3. The healthy buds blossom about the same time that the injured buds fall off. The effect of the loss of the blossoms on the character of the grape cluster is shown in Plate XLI. While the loss in the amount of fruit is considerable, the greatest loss results from the poor quality of the clusters when fancy grapes are at a premium.

The larvæ feed upon the pistil of the blossom and also may injure the style and stigma, but they have not been found feeding on the stamens. The larvæ do not appear to feed on the petals or calices, and it is believed that the swelling and gall-like formation of these parts of the flower are due to a stimulating effect of the products of excretions on the petals and calices.

DESCRIPTION OF INSECT.

Egg.—The eggs were not found in the blossom buds although many attempts were made to locate them after seeing the midges apparently deposit eggs. A number of midges were dissected and the eggs found. They are of a translucent, gray appearance, elongated, rounded at both ends and the entire egg slightly curved.

Larva.— The young larvæ (Plate XL, fig. 4) are from 1.5 to 2 mm. (.06 to .08 inch) in length, are nearly transparent and colorless, but as they grow older they assume a bright yellow and even an orange appearance. They have 14 segments in the body while the larvæ of all other insects, except those belonging to this family, have 13 segments. The supernumerary or additional segment is placed between the head and the first thoracic segment.[4] The larvæ have nine pairs of stigmata or breathing pores which form nipple-shaped projections. Those on the penultimate segment form two cylindrical processes. The head is short and narrow and the mouth parts are imperfectly formed; antennæ short, stout and without joints. These larvæ (as do the larvæ of many other Cecidomyiidæ) have peculiar, forked, horny plates on the under side of the body at the junction of the first thoracic

[4] Williston, S. W. Manual of North American Diptera, p. 120. 1908.

segment and the supernumerary segment, which have been called "the breastplate" by Osten Sacken.[4] The function and homology of this part are unknown. This breastplate is bidentate, the teeth broadly triangular, the basal part tapering and partially transparent. The skin is very smooth and has a shiny appearance, and the body segments are distinct. The anal segment is rounded, with two setæ and within these a pair of tubercles or processes which Girard[5] says are used by similar larvæ for leaping, and which he calls corneous papillæ.

Pupa.—Two pupæ were found May 1 and 3, 1910, by searching soil taken from under vines that had been badly infested in 1909. The pupæ when found were naked, but the fact that hibernating larvæ taken from the soil in November, 1910, were in a delicate cocoon, leads the author to believe that the larvæ transform to pupæ within these cocoons and that the two specimens of pupæ found had had the cocoons broken by stirring the soil and so appeared naked. They resemble small lepidopterous pupæ (Plate XLII, fig. 1). Much time was spent in an effort to secure a number of the pupæ but only two were found. The pupæ varied somewhat in size and appearance and are described as follows:

1. Size 1.14 mm. x .326 mm. (.045 in. x .013 in.) Color of body light orange, abdomen showing 8 segments. Eyes light brown and compound. Head with two bristle-like setæ projecting from the vertex. These setæ were .18 mm. in length and arose from tubercular-shaped bases. Wings were hyaline (almost white) and were folded over the thorax, the distal parts meeting under the abdomen. This pupa was carefully placed in a vial with earth and transformed into a male midge May 18th.

2. Size 1.304 mm. x .489 mm. (.05 in. x. .02 in.); color of body a lemon yellow; abdomen showing eight segments; the head having two setæ projecting from the vertex. These setæ were 2.25 mm. (.09 in.) in length. Two strong setæ projected from the top

[4] Williston, S. W. Manual of North America Diptera, p. 120. 1908.

[5] Girard. *Bull. Soc. Ent. France,* 1893, p. 80 (reference from Sharp's Insects, II, p. 460).

of the thorax and were .15 mm. (.06 in.) in length. Eyes dull, not much different in color from the body, compound. Wings hyaline, folded over the thorax, meeting under the abdomen. Owing to the great difficulty of securing pupæ, this specimen was preserved. This pupa being larger than the preceding would indicate that it may be a female.

Adult.— The adult insects are very small and delicate. They have a yellowish-colored body and long, thin, straw-colored legs. The body and legs have much hair. The wings are transparent, with several prominent veins. The eyes are dark, kidney-shaped and compound.

The male (Plate XLII, fig. 2) is only 1 mm. (1/25 of an inch) in length and has antennæ or feelers one-half longer than the body. These are knobbed and at first sight appear to have twenty-six segments, but in reality have fourteen since each joint after the second has two globular enlargements. These are thickly set with whorls of hair.

The female (Plate XLII, fig. 3) has shorter antennæ than the male. They are less than the length of the body and have bead-like enlargements. There are fourteen segments and each segment has a single enlargement. The body is larger than that of the male, being 1.5 mm. (about 1/16 of an inch) in length. The antennæ of the female are not so thickly set with setæ as the antennæ of the male. The long, fleshy ovipositor is provided with a lash-like organ, whose function appears to be to brush a place for the eggs.

The technical description as given by Dr. Felt[6] is here quoted

TECHNICAL DESCRIPTION.

"*Male.*— Length 1 mm. Antennæ one half longer than the body, thickly haired, fuscous yellowish; 14 segments, the fifth with the basal portion of the stem with a length one-half greater than its diameter, the distal part with a length three times its diameter, the enlargements subglobose, the basal one with a sparse subbasal whorl of setæ, the circumfilum with the loops sparse, long and extending to or a little beyond the middle of the subglobular distal enlargement, which latter has a scattering subbasal whorl of curved

[6] Felt, E. P. N. Y. State Mus. Bul. 134, pp. 17–18. 1909.

setæ and a similar circumfilum, the loops extending to the base of the following segment. Palpi: first segment short, subquadrate, the second stout, with a length over three times its diameter, the third a little longer, more slender, the fourth one-fourth longer than the third. Mesonotum fuscous yellowish. Scutellum and postscutellum yellowish. Abdomen fuscous yellowish; genitalia darker. Wings hyaline, costa light brown, subcosta uniting therewith before the basal third, the third vein at the apex; fringe abundant. Halteres whitish transparent. Legs mostly pale yellowish; claws long, slender, evenly curved, the pulvilli as long as the claws. Genitalia: basal clasp segment stout, truncate; terminal clasp segment rather stout, slightly tapering; dorsal plate short, deeply and triangularly emarginate, the lobes diverging, obliquely truncate and sparsely setose; ventral plate long, very deeply and roundly emarginate, the lobes long, slender, with a few coarse setæ at the narrowly rounded apex; style, short, stout."

"*Female.*— Length 1.5 mm. Antennæ nearly as long as the body, rather thickly haired, fuscous yellowish, yellowish basally; 14 segments, the third greatly produced, with a length six times its diameter, the fifth subsessile, cylindric, with a length two and one-half times its diameter, slightly constricted near the basal third, subbasal and subapical whorls rather thick, short, strongly curved; terminal segment somewhat produced, the apical fourth forming a broadly rounded knob. Mesonotum fuscous yellowish, the submedian lines sparsely haired. Scutellum and postscutellum fuscous yellowish. Abdomen a little lighter, the distal segements slightly fuscous. Halteres pale yellowish. Coxæ, femora and tibiæ mostly pale straw, the anterior and midtarsi fuscous yellowish, the posterior tarsi apparently pale yellowish. Ovipositor nearly as long as the body, the terminal lobes with a length six times their width, very slender, subacute apically and with a few coarse setæ."

SEASONAL HISTORY.

Adult.— The emergence of the adults from the soil under the trap cages began May 19, 1910, and continued until June 6, but the period of greatest emergence was from May 21 to May 27. The emergence in the cages was earlier than from the soil in the vineyard since the ground covered by the cages was warmer by several degrees than the surrounding soil. Every effort was made to prevent this but even the use of fine, white muslin did not obviate this trouble. It was desired to get accurate vineyard conditions as a guide for the control measures that were planned. The records of these cages are given in the following table:

TABLE IV.—RECORDS OF EMERGENCE OF GRAPE BLOSSOM MIDGE IN TRAP CAGES. FREDONIA, 1909.

No. of cage	3 ad	3 ae	3 af
Variety	Moore Early	Moore Early	Worden
Vineyard	H. L. Cumming	H. L. Cumming	H. L. Cumming
Started	May 16	May 17	May 17
May 19	5 midges	0 midges	0 midges
21	60 "	0 "	0 "
22	75 "	0 "	0 "
24	57 "*	0 "	0 "
25	19 "†	0 "	0 "
27	0 "	24 "‡‡	0 "
June 6	2 "‡	7 "**	1 "‡
Total	218 "	31 "	1 "

* 9 male, 48 female.
** 2 male, 5 female.
† 4 male, 15 female.
‡ Females
‡‡ 9 male, 15 female.

The placing of the cages was rather a matter of chance and it is believed that some of the cages were placed under vines which had few midge larvæ in 1909.

The adult midges being very small, it is difficult to see them on the vines, but the vines were carefully watched for adults from May 19th to June 6th. It was found helpful to use a medium-sized reading-glass to examine the blossom-bud clusters for midges, but with every aid no midges were found on the clusters. The spider webs in the vineyard and vicinity were carefully watched and one male midge was taken in this manner June 3d.

INFLUENCE OF THE WEATHER ON EMERGENCE.

The weather is an important factor in the emergence of the midges. From May 19th to 27th the weather was warm and the sun shone many of the days, but from May 28th to June 6th the weather was cold, with rain and cloudy days. A glance at the above records would indicate that this affected the emergence of the midges very much.

In comparing the infestation of grapes by the blossom midge about Fredonia and Westfield in 1909 and 1910, it is to be noted

that infestation by the blossom midge could be found in almost every vineyard in 1909. This varied from a slight infestation of about one per ct. to 60 per ct. of the buds injured but in 1910 there was a great scarcity of injured buds in all vineyards except that of Mr. Cumming, and in this vineyard the infestation was less than 10 per ct. of the blossom buds where between 50 and 60 per ct. were infested in 1909.

At the time the adult midges were emerging in the vineyard there were clear days followed by rain and cold weather, and this is believed to have killed off many of the adults before egg deposition had taken place.

Feeding habits of adults.— It is not known whether the adults feed or not, but the short life and the imperfectly formed mouth parts of the adult would indicate that they do not require food.

Mating.— The adult flies mate soon after emerging from the soil. The mating of one pair was observed in part. When first seen the male and female had paired by placing the ends of the abdomens together. During the act of copulation the female appeared restless and wandered about while the male assumed a lifeless appearance, thus allowing the female to drag him about for several minutes, when the male suddenly revived and tore himself from the female. The length of life after copulation appears to be short. The pair observed were placed in a cage on a blossom-bud cluster in order to get egg-laying records. The male was dead by the following morning. It was extremely difficult to find the sexes mating. They apparently mated shortly after emerging in the trap cages, for in taking the insects from this cage and watching the actions of a large number of females it was found that they almost immediately would begin ovipositing.

In one cage, which consisted of a mica chimney placed over a blossom cluster, were placed four female midges taken from the trap cages, but the water transpiring from the cluster collected on the sides of the cage and the midges drowned. Several of the buds showed injury two weeks later, although the cluster had been kept enclosed, so mating must have taken place while in the trap cage.

Egg deposition.— The tiny insect bends its head down so that the middle joints of the antennæ touch the surface of the buds she is about to walk upon. In this position she wanders in a nervous manner over different buds in the cluster, apparently feeling with her antennæ to find a bud suited for oviposition. When such a bud has been found the insect almost always places her body over the apex of the bud and after arching the body gradually forces out a long telescope-formed fleshy ovipositor which she proceeds to push through the opening in the apex of the bud. Just before inserting the ovipositor there is pushed out from the distal segment of the ovipositor a lash-like organ with which the female appears to brush portions of the bud. Having performed this operation she inserts the ovipositor into the bud and appears to curve it forwards so as to place the egg on the inside of the petal. It may also happen that the egg is dropped into the bud and is not fastened. During this operation the female is motionless from a few seconds to a minute, except for a movement in the ovipositor which is seen as the egg is passing down. Having deposited the egg the female walks to another bud and repeats the process. She will, often, return to the same bud and deposit more eggs. The ovipositions that were timed required an average of one minute and fifteen seconds.

The female midge does not appear to be able to oviposit by piercing the tissues with her ovipositor, so that advantage is taken of those buds having an opening at the apex. It is a common observation that Concords are seldom so badly infested as the earlier varieties such as Moore Early, Worden, Champion and Massasoit. Having learned the preferences of the insect, a number of buds of Concord and Moore Early growing within fifty feet of each other were examined and it was found that the Moore Early had many more open buds than the Concord. Females were seen ovipositing at various times throughout the day but were most active when the weather was warm. Cold weather caused them to be inactive.

It appears that the female midges begin ovipositing very soon after mating, for females taken from the cage would begin ovi-

positing as soon as they were supplied with blossom buds, provided the weather was warm. The number of eggs laid by a single female was not determined, but the females dissected had thirty-eight and forty eggs each. The females do not appear to feed before laying eggs. The adult stage is very short. The males lived but a short time, usually not over two days after emerging. The females lived longer, but in none of the cages were they found to live more than four days. These insects are so frail and delicate that it was with difficulty that they were kept alive in the cages.

Larva.— The larvæ hatched about the 1st of June, 1910, and by June 6th clusters in the cages began to show injured buds. The injured buds in the vineyard were numerous by June 10th. The larvæ began to leave the buds in some of the cages June 19th, and in the vineyard June 21st. By June 24th all had gone into the ground. The Moore Early and Worden grapes began to bloom June 23d. Thus the larval stage in the buds is about three weeks.

The feeding habits of the larvæ are but partially understood. The fact that the pistils are injured either by scraping or biting would indicate that the horny breastplate is used to scrape off portions of the plant for food since the incomplete mouth parts would scarcely be adapted for this use. Nothing is known of the feeding habits of the larvæ after reaching the ground.

When the larva has reached its full development in the bud, which is a few days preceding blossoming, it leaves the bud either by crawling out of the opening at the apex or by making a hole in the side of the bud (the latter is the less common manner) and, crawling about on the exterior of the bud, it has a curious fashion of forming its body into a loop by bringing the head and anal segment together,— perhaps joining the corneous papillæ with the breast bone, — then, by straightening the body suddenly, throws itself some distance. This may be from only a few millimeters to between 30 and 40 millimeters (.125 to 1.5 inches). Usually this throwing of the body or leaping is sufficient to allow the insects to drop to the ground, into which they imme-

diately begin to burrow. In glass tubes they have been observed to burrow to a depth of six inches. Dr. Felt says that "they remain in an earthen cocoon during the rest of the season and transform to pupæ the following spring." The author has verified this statement and found that the larva forms a lining to this earthen cocoon which has a tan or straw color. (Fig. 4.) It resembles the cocoons of certain small moths. Two such cocoons were found November 19, 1910, in the soil of a cage consisting of a glass cylinder placed in the soil. The cocoons were found at a depth of six inches and were oval in shape, being .97 mm. by .75 mm. (.04 in. by .03 in.). The larvæ were curled inside. A comparison was made between these larvæ and those taken as they were leaving the buds. The only difference that could be found was a difference in size. Two larvæ taken from buds were 1.9 mm. and 1.75 mm. (.075 in. and .07 in.) in length and the hibernating larva was 1.65 mm. (.065 in.) long.

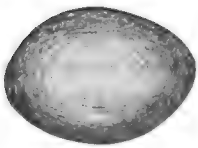

FIG. 4.— HIBERNATING COCOON OF GRAPE-BLOSSOM MIDGE. (Much enlarged.)

Pupa.— It is evident that the larvæ do not change to pupæ until spring, but the only observations made by the author are upon the two pupæ found May 1 and 3, 1910. The midges appearing the latter part of May and the early part of June show that the pupal stage lasts at least three weeks.

SUMMARY OF LIFE HISTORY.

The eggs are laid in the blossom buds of the grape during the latter part of May and the early part of June and hatch in a short time into the larvæ or maggots which live between two and three weeks in the blossom buds feeding on the pistil and then migrate to the soil. Here they form earthen cocoons lined with a silk-like material and pass the winter. It is believed that they transform to pupæ in this same cocoon. The larval stage extends over a period of ten or eleven months. The pupal stage extends from the latter part of April until the latter part of May when the adults emerge. The adults mate and the males soon die. The females deposit the eggs for the next generation and then perish.

EXPERIMENTS DURING 1910 TO CONTROL THE GRAPE-BLOSSOM MIDGE.

In planning methods of control the following facts were considered: the frailty of the insects, their susceptibility to nicotine fumes, and the care with which the females select places to deposit their eggs.

It, therefore, was thought that by spraying strong solutions of one of the tobacco preparations on the vines many of the insects would be killed as they attempted to lay their eggs. A number of vines were sprayed with various strengths of the nicotine preparations. Since the female is very careful in selecting a place to deposit her eggs it was considered possible to spray with substances like bordeaux mixture and various strengths of lime-sulphur and thus repel the insects. The following table summarizes the results of the sprayings:

TABLE V.—RESULTS OF SPRAYING EXPERIMENTS AGAINST GRAPE-BLOSSOM MIDGE.

Experiment	MATERIAL USED.	Number vines	Number clusters	Total infested buds.	Maximum injured buds	Minimum injured buds	Average injured buds per vine	Average injured buds per cluster
3 at	Lime-sulphur 1–40....	22	794	1,867	215	0	84.9	2.35
	Check............	4	179	425	156	57	106.25	2.37
3 au	Lime-sulphur 1–50....	24	847	2,612	235	0	109.00	3.08
	Check............	4	144	535	186	28	133.75	3.72
3 av	Lime-sulphur 1–60....	22	681	1,133	136	4	51.50	1.66
	Check............	4	100	481	241	55	120.25	4.81
3 aw	Lime-sulphur 1–60.. Tobacco ext. 1–50..	22	761	838	99	3	38.10	1.10
	Check............	4	126	628	176	141	157.00	5.00
3 ax	Tobacco ext. 1–30....	20	708	1,157	143	2	57.85	1.63
	Check............	4	146	614	257	62	153.50	4.21
3 ay	Tobacco ext. 1–50....	22	850	1,529	157	7	69.50	1.79
	Check............	3	127	501	184	146	167.00	3.94
3 az	Tobacco ext. 1–70....	22	774	2,536	292	7	115.27	3.27
	Check............	4	153	817	274	143	204.25	5.34
3 ba	Whale-oil soap..... 1 lb. to 12 gals. water	21	787	605	99	3	28.81	0.77
	Check............	4	147	343	176	6	85.75	2.33
3 bb	Resin fish-oil soap... 1 lb.–12 gals. water.	21	842	1,462	183	4	69.62	1.73
	Check............	4	189	575	293	77	143.75	3.04
3 bc	Bordeaux mixt. 4-4-50.	20	756	2,318	218	37	115.90	3.07
	Check............	2	94	345	213	132	172.50	3.67
3 bd	Bord. mixt. 4–4–50. Tobacco ext. 1–60...	24	614	990	246	3	41.25	1.61
	Check............	4	137	186	81	41	46.50	1.36
3 be	Atomic sulphur 1–40..	19	766	2,101	268	28	110.58	2.74
	Check............	4	170	509	140	117	127.25	2.99
3 bf	Molasses 1 qt.–6 qts. water..........	20	772	1,312	157	5	65.60	1.7
	Check............	2	81	355	237	118	177.50	4.38
	Total............	326	11,745	26,774	.....	....	......	....

An average vine was selected and the clusters and buds counted. This is summarized in the following table:

Number of clusters	20
Number of blossom buds	1,021
Maximum buds on cluster	110
Minimum buds on cluster	8
Average buds on cluster	51

The vine having maximum infestation per cluster had 5.34 injured buds per cluster. If we assume the clusters to have had an average of 51 buds the percentage of infestation was 10.5.

A comparison of the results of the various control measures in the table shows:

1. The lime-sulphur solutions apparently were ineffective except that when used at 1-60 there appeared to be a reduction in the number of infested buds. The foliage was severely burned on every vine sprayed with this solution.

2. The tobacco extract when used not weaker than 1-50 gave a substantial decrease in the number of injured buds.

3. Both the whale-oil soap and resin fish-oil soap now show a decrease in infestation over the check vines.

4. The bordeaux mixture gave poor results as a repellent.

5. The "Atomic Sulphur and Arsenate of Lead" was practically useless for the midge.*

6. The use of molasses at the rate of 1 to 6 was beneficial.

Weather conditions mentioned above interfered with the spraying. Two sprayings were applied May 26 and June 4 and a few days after each spraying there was a period of rainy weather. This, no doubt, interfered with securing the best results. It will be necessary to repeat these experiments to verify this season's results. However the tests indicate that nicotine preparations, whale-oil soap, and perhaps some adhesive preparations may be useful in controlling the midge.

[* This material has good qualities as a fungicide and as a poison for chewing insects, but the results from its use in this experiment are similar to those obtained by bordeaux mixture. It was tried as an experiment even though the manufacturers did not recommend it as a contact insecticide or a repellent.]

METHODS OF CONTROL.

Clean culture.— Much has been said regarding clean culture in efforts to control insects. Observations indicate that with most grape insects this is not a method of control. In fact, some of the cleanest vineyards are most badly infested with various pests. Then, too, we are learning that clean culture which leaves the ground bare between August and the following spring is not good horticultural practice. Moreover, the vineyard of Mr. Cumming has been well cared for and has had clean culture, so it is not believed that this practice will be of much value in the control of the midge.

Smoke and smudges.—The practice of using smoke and smudges to control the midges has been suggested, but the vines had already been sprayed and this method was not tried. The emergence of the adults occurring during a period of two weeks might make this impracticable as it would be necessary to use the smudge every day and for a considerable portion of the day. However, since the midges are active principally on the warmer days and do not emerge during bad weather, a few applications of the smudge on the fairer days might suffice to control the oviposition of the midges. One objection to this method is the uncertainty of the exact dates the adults will appear, it being very difficult to find the adults on the vines.

Spraying.— The idea of placing materials on the vines either of an adhesive or repellent nature or substances that would kill the adult midges as they are seeking to lay their eggs is considered the most practicable method since one or two early applications would be sufficient to control the midges without the necessity of one's presence in the vineyard every day while the midges are emerging.

The results of experiments would indicate that a nicotine preparation such as the tobacco extract used in the experiments would assist in reducing the number of eggs deposited and thus lessen the number of injured buds.

Molasses or other adhesive substances may be of value in killing the adults but these require more experimentation to prove their actual value.

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1908. Felt, E. P. *Grape Belt*, June 12; *Buffalo News*, June 13; *Country Gentlemen*, June 18, 73:607; *Jour. Economic Ent.* 1:243 (Brief records of injury as Cecidomyia).

1909. ———— . *Grape Belt*, May 18 (Records rearing of adult, outlines the life history and discusses remedies).

1909. ———— *Jour. Economic Ent.* 2:257 (Records rearing adult and discusses importance).

1908. ———— 24th Report of State Entomologist of New York. Bul. N. Y. State Museum No. 134, pp. 15–19 ((Account of the injuries and life history of the insect. Original descriptions of the larvæ, male and female. Remedial measures discussed).

THE ROSE-CHAFER.

Macrodactylus subspinosus Fabr.

ORDER Coleoptera. FAMILY Scarabæidæ

INTRODUCTION

The rose-chafer, or "rose-bug," is a rather common insect in the eastern United States and Canada where there are many accounts of its ravages. It is chiefly a grape insect but causes damage to other cultivated fruits. The rose-chafer is common throughout New York State and has caused much damage in the past. This species has been frequently mentioned by many of the entomologists of this State.

Since the insect has been so very destructive, advantage has been taken of its annual occurrence in injurious numbers to make studies and observations on its life history, especially regarding the time of its various transformations, and to try methods for its suppression.

ECONOMIC IMPORTANCE.

The literature of economic entomology abounds with records of the destructiveness of this insect. It injures grapes and cherries to a greater extent than other plants, but it has done serious damage to apples. Nor are its ravages confined to these fruits, since much loss has been recorded on raspberries, blackberries, straw-

berries and flowering plants, due to the appetite of this ravenous insect. The beetle attacking the flowers can do an immense amount of damage in a short time, but it is chiefly owing to its great numbers that it works such havoc. In the vineyard at Westfield these insects were so very numerous that every cluster was a mass of the crawling beetles. They soon ate the blossoms and thus destroyed the crop. In 1909 the two acres of Niagaras in Mr. Bourne's vineyard gave a gross income of $2.35 which should have yielded a crop worth about $200 at the prices paid that year. In 1910 these two acres gave a gross income of $99.90, which was about half the amount an average crop should have sold for. The increase in the value of the crop was due to control measures which were conducted in 1910, but since the materials used on many of the vines were unsuccessful in checking the rose-chafer the loss on these sections was still very great. This made an average decrease of nearly $100 in the gross receipts. The continued depredations of the hordes of beetles, with the inability of vineyardists to cope with them have been the cause of the pulling out of many vineyards in New Jersey, Ohio and Pennsylvania during the past twenty years. Whether the pests will ever extend over much of Chautauqua grape section is not known, but since the insect breeds in sandy and gravel soils there is a possibility of its becoming established in many acres of soil either planted to grapes or near vineyards. There is reason to believe that the Westfield infestation will be confined to its present area and there is hope of exterminating it here.

HISTORY.

The rose-chafer was described by Fabricius who gave it the scientific name *Melolontha subspinosus.* Latreille established the genus Macrodactylus and placed this species in the genus, thus giving it the present name of *Macrodactylus subspinosus.* The generic name means long toe or long foot since the foot, or tarsus, constitutes more than half the entire leg. The specific name refers to the shape of the thorax which is long and narrow and has two rather angular projections on either side, which are somewhat spined.

The first published account of the economic importance of this insect was by J. Lowell [1] in 1826, which was followed in the next year by a partial account of the life history by Harris.[2] This author studied the life history carefully and an excellent description of the habits and destructive work of this beetle is given in his "Insects Injurious to Vegetation" (1841, '52 and '62 editions). This description has scarcely been improved to the present day. Many other entomologists have given short accounts of the distribution and the destruction wrought by this insect. The accounts given until 1890 dealt mainly with food plants, destructiveness and distribution, with various recommendations for control. The next important account of the insect is that given by Dr. C. V. Riley.[3] He summarized the then known facts regarding the biology, distribution and injuries of the insect as well as the various attempts at control. In 1891, Dr. J. B. Smith,[4] State Entomologist of New Jersey, made extensive studies on the habits and methods of control. His researches have given us additional facts regarding the habits of this destructive insect and his methods proved conclusively that the rose-chafer is an exceedingly difficult insect to control. The writings of all the entomologists place great emphasis on its capacity for harm and its resistance to ordinary spraying mixtures.

The bibliography of the "rose bug" is extensive. Most of the economic entomologists have given contributions to our knowledge of the insect. It has been found in injurious numbers at various times throughout almost its entire range for over a century.

ORIGIN AND DISTRIBUTION.

The rose-chafer is an American insect and occurs from Maine and the New England states westward through New York and Ontario to southern Minnesota, thence southward and westward including Iowa, Nebraska to Colorado, New Mexico and Texas.

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[1] Lowell, J. *Mass. Agr. Repos. and Jour.* 9:143–147. 1826.
[2] Harris, T. W. *Mass. Agr. Repos. and Jour.* 10:1–12. 1827.
[3] Riley, C. V. *Insect Life,* 2:295–302. 1890.
[4] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

East of the Mississippi river, it occurs as far south as North Carolina and Tennessee. (Map, fig. 5.) In literature this species is re-

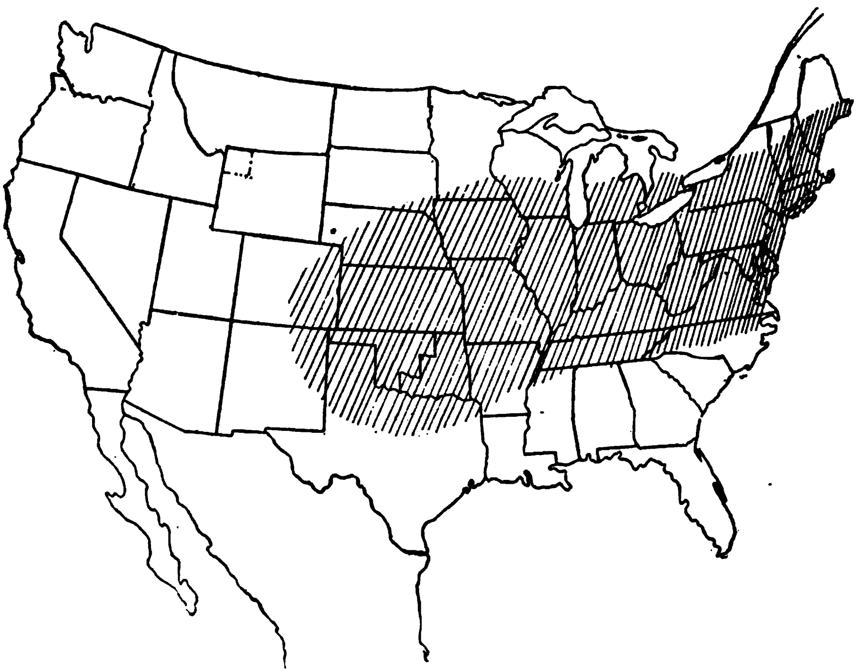


FIG. 5.—DISTRIBUTION OF THE ROSE-CHAFER.

ported from the following states and Canada: Colorado (Chittenden, Quaintance), Connecticut (Britton), Delaware (Beckwith, Sanderson), Illinois (Walsh, Thomas), Indiana (Walsh, Riley, Webster), Iowa (Kulp, Osborne), Kansas (Riley), Maine (Patch, Johannsen), Maryland (Johnson, W. G., Chittenden, Quaintance), Massachusetts (Howell, Harris, Walsh, Chittenden), Michigan (Cook, Pettit,) Minnesota (Lugger, Washburn), Missouri (Riley), Nebraska (Bruner, Hunter), New Hampshire (Harris, Weed, Sanderson),New Jersey (Hulst, Pearson, Smith), New York (Fitch, Lintner, Treat, Slingerland, Felt, Parrott),

North Carolina (McCarthy), Ohio (Kirkpatrick, Weed, Webster, Mally, Snyder, Newell), Oklahoma (Bogue), Ontario (Bethune, Saunders, Fletcher, Lochhead), Pennsylvania (Walsh, Johnson, C. W., Surface, Johnson F., Hammar), Rhode Island (Kinney, Southwick), Texas (Riley, Wickson), Vermont (Perkins), Virginia (Riley, Howard, Alwood, Chittenden, Quaintance), Wisconsin (Brues, Sandsten).

From the literature we learn that this insect has a range farther north than the root-worm and slightly farther than the grape flea-beetle. However the latter species has a much greater distribution to the south, being found in all the Gulf states.

The rose-chafer has been found in almost all parts of New York and is chiefly reported from the fruit-growing sections. In Chautauqua county it has gained a foothold in an area of about twenty acres near Westfield. It has been reported from a vineyard in Erie county, N. Y., and is found in several localities in Erie county, Pa., in the grape regions.

FOOD PLANTS.

The insect feeds on almost every plant except evergreens found within the limits of its range. It shows decided preference, however, for many plants, of which the grape unfortunately ranks among the first. Among cultivated plants, trees and shrubs, apple, rose, cherry, pear, plum, quince, blackberry, raspberry, strawberry, magnolia, poppy, hollyhock and foxglove are recorded as being destroyed. It is said to attack willow, alder, tulip trees, sassafras, sour gum, oak, fern and bracken. The author found the beetles feeding at Westfield, in addition to the above, on hawthorn (*Crataegus sp.*), black walnut (*Juglans nigra*), smoke tree (*Rhus cotinus*), sumac (*Rhus glabra*), dog wood (*Cornus stolonifera*) and elder (*Sambucus canadensis*).

Since the rose-bug feeds chiefly on the flowers it shows a tendency to migrate from one species of plant to another as they begin blossoming. At Westfield the following migrations were noted: The Concord and Niagara grapes began to blossom about the time

the beetles emerged, and were first attacked. After feeding on the blossom of the grape for a period varying between ten days and two weeks the beetles would leave the grape and feed upon the sumac (*Rhus glabra*) which begins to blossom at this time. Here they fed until most of the beetles had died, but a few chafers were found feeding on the flower of the dog wood (*Cornus stolonifera*) and the common elder (*Sambucus canadensis*), as late as Aug. 1, 1910.

CHARACTER AND EXTENT OF INJURY.

Grape growers are fortunate in having so small an infestation, as the records of its injuries to grapes in Erie Co., Pa., in Ohio and in New Jersey show it to be a most serious pest where it is established. In some localities owners have pulled out their vineyards and have resumed general farming owing to the repeated losses from the rose-chafer. During the month of June when the grapes are blossoming the owner of a vineyard may find that his vines are covered with large, awkward, yellowish-brown beetles. He will also notice that the majority of the beetles are feeding on the blossoms of the grape and, if the infestation is severe, from one to a dozen of the beetles will be found on every blossom cluster, which will be stripped in a few days of almost every flower. Having destroyed the blossoms of the grape the beetles attack the leaves and the berries and after feeding on the grape from ten days to two weeks they fly to other food plants, which include almost every plant that is in blossom at that time. They are especially fond of the flowers of the rose and spoil many by eating the petals. It was because of injuries to roses that the insect received its common name.

A common result of their feeding on the berries of the grape, when they are about the size of No. 1 shot, is seen later in the summer in the protruding of the seeds from the sides of the berries (Plate XLIII, figs. 1 and 2). The results of their feeding on the blossoms and the young berries may be seen in Fig. 3 of the same plate.

In some localities the apple, pear, plum and cherry trees are a mass of crawling beetles during severe infestations and the fruit of these trees is entirely destroyed or marred so as to be practically worthless. Dr. Smith[5] reports that in New Jersey these beetles have done great mischief to flower gardens, eating the flowers of almost every plant in the gardens but seem to refrain from eating the flowers of larkspur.

DESCRIPTION.

Egg.— The eggs of the rose-chafer are small oval bodies having a smooth, shining, white appearance (Plate XLIV, fig. 1). They average 1.2 mm. (.05 inch) in length and .7 mm. (.03 in.) in width. Of sixteen eggs measured the length varied from .9 mm. to 1.3 mm. (.035 in. to .05 in.) and the width varied from .64 mm. to .79 mm. (.025 in. to .032 in.).

Larva.— The body of the larva is white except the posterior portion which is of a dark color owing to remains of the food showing through the body wall (Plate XLIV, fig. 2). The spiracles are a light brown. In shape the larva much resembles a white grub (the larva of a Lachnosterna beetle) but is smaller. The full grown rose-chafer larva is about 20 mm. (.8 inch) in length and 3 mm. (.12 inch) in width. The head is yellowish-brown. The mandibles or upper jaws have two projections on the inner margin and are dark brown with the tips black. The clypeus or upper lip is light brown and has many strong setæ along the anterior margin. The lower side of the clypeus has a prominent ridge which forms a loop-shaped prominence and is covered with very many short, sharp setæ which are used in feeding. The maxillæ or lower jaws are fitted with heavy chitinized teeth-like setæ while the lower lip, or labrum, is covered with shorter hairs. The antennæ are short, with four segments, and light in color. The head and body are thickly covered with many bristle-like hairs. The feet are dark and have prominent setæ.

Pupa.— The pupa is of a light yellowish-brown color and is

[5] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

about 15.6 mm. (.6 inch) in length. It has the shriveled larval skin clinging to the posterior segment. The developing legs are very prominent.

Adult.— The body of the adult is about 12.5 mm. (.5 inch) in length and has a general appearance of yellow and brown (Plate XLIV, fig. 3). The head and the thorax are black but are covered with a number of yellow hairs which give those parts a lighter appearance. The wing covers, or elytra, have a brown color and are also covered with yellow hairs. The legs of the insect have a dark reddish-brown color and the long feet or tarsi are black. The antennæ of the rose-chafer differ very much from those of the grape root-worm and grape flea-beetle, bearing knob-like structures at the tips. These structures are composed of thin plates which the insect can open and close, and are perhaps used for the purpose of smelling.

SEASONAL HISTORY.

Emergence of adults.—The adult beetles began to appear June 17, 1910, and the majority had emerged by June 22d. During the day of June 21st the air seemed filled with beetles which came from grass fields and were migrating to the vines. At this time the vineyard was being sprayed and the beetles alighted on one's hat and clothes, and in numbers on the spraying machine. They emerge during the warmer parts of the day. The date of appearance varies each year but is coincident with the time the grapes begin to blossom.

Feeding habits of adults.—Almost immediately upon reaching the vines the beetles begin to feed upon the blossoms, and apparently feed nearly a day before beginning mating, but the females feed even while mating. The beetles are slow-moving and clumsy as they crawl about the vines and will not fly unless much disturbed. They feed on the blossoms first and when this supply is exhausted they feed on the leaves of the grape. (Plate XLIV, fig. 4.) After feeding from ten days to two weeks they migrate to other food plants, especially those in blossom, as has been described above.

Mating.— These beetles are conspicuous by their mating habits, since many of the beetles are found copulating during the time they are feeding on the grape and even later. Mating is almost continuous until the eggs are deposited,— a period of several weeks. Copulating couples have been seen as late as July 20th.

Egg deposition.— The females prefer to deposit their eggs in light, sandy soil, and observations indicate that they do not deposit in heavy soils. A glance at the map (Fig. 6) will show that the infested vineyard has two distinct kinds of soil: a light, sandy soil occupying the more elevated and thus better drained portions of the vineyard; and a heavier, loam soil which usually occupies the lower and poorer drained portions of the vineyard. The south end of the vineyard is on a soil intermediate between these two kinds. In digging for larvæ it was learned that they are found in the sandy soil both in the vineyard and in the fields on each side. The greatest damage to the grapes was to be found in the sandy portions of the vineyard. Larvæ were never found in the heavier loam. There remains the possibility that eggs may be laid in the heavy soil, but that they do not hatch. Efforts were made to secure egg-laying records of individual beetles, but the beetles did not behave naturally and the number of eggs deposited was small. Dissection of female beetles gave various numbers of eggs ranging from thirteen to thirty. Dr. J. B. Smith[6] studied the egg-laying habits of this insect and found that the number of eggs varied from twenty-four to thirty-six. The females lay most of their eggs during a period of three weeks, extending from June 25th to July 15th, but it is possible that deposition is continued until August. In cages the last eggs were laid July 7, 1909, but the presence of copulating couples on July 12th in the vineyard showed that egg-laying was continued until a later date in the open. In 1910 eggs were found June 28th and deposition extended until about July 20th with most of the beetles, though the presence of female beetles as late as August 1st would indicate a later date for the last eggs.

[6] Smith, J. B. N. J. Agr. Exp. Sta. Bul. 82. 1891.

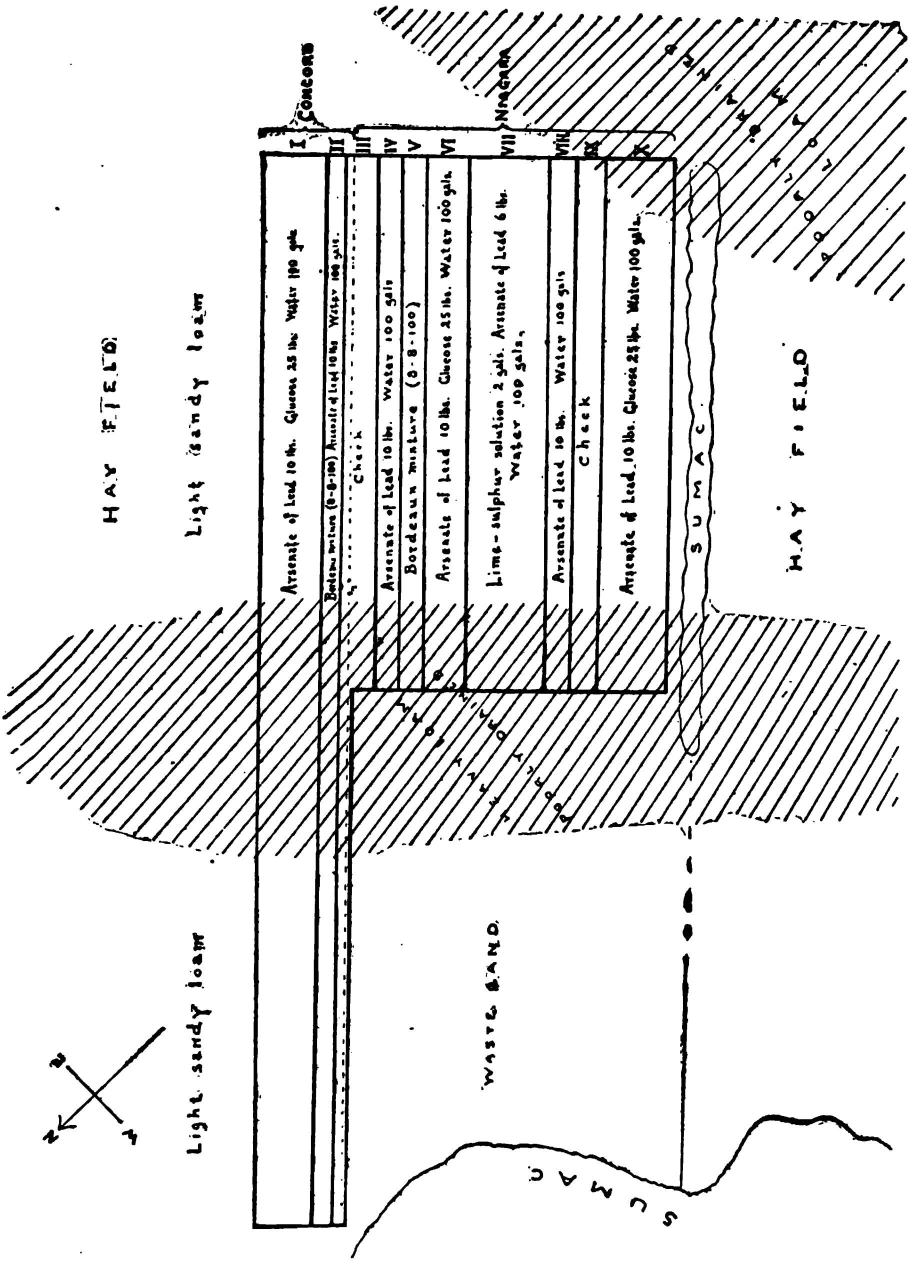


FIG. 6.— MAP OF BOURNE VINEYARD; ALSO SHOWS SPRAY TREATMENTS APPLIED JUNE 28.

Egg.— The egg stage occupies a period of between two and three weeks. Hatching occurs during the last week in July and first week in August.

Larva.— The young larvæ were found in the soil the last week in July and were feeding on the roots of the fox-tail grass (*Setaria glauca*) and of timothy (*Phleum pratense*), at Westfield. They were never found feeding on the roots of the grape. The number of larvæ in the soil varies. One square yard of soil to a depth of six inches in September, 1909, produced 175 larvæ, while the number in the hay field east of the vineyard (same kind of soil) was 20 per square yard. They were found in the hay field west of the vineyard in about the same number. The larvæ reach full growth by November when they burrow to a depth of about a foot, form a larval chamber and pass the winter. Early in the spring they again crawl nearer the surface and may resume feeding. The larval stage lasts nearly ten months.

Pupal stage.— The larvæ form cavities in the soil from three to six inches below the surface and here change to pupæ. This change depends on the weather, but in 1910 the first larvæ changed to pupæ May 25th. Some larvæ did not change until June 2d. The pupal stage lasts between three and four weeks, the first adults emerging June 17, 1910. The majority of the adults did not emerge until June 21st and 22d.

HISTORY OF INFESTED VINEYARD.

Mr. Fred Gladwin, in making the horticultural survey of the various vineyards in the county, found this vineyard June 27, 1909, and communicated the fact to the author. A visit to the vineyard the following day revealed the fact that most of the vines situated on the sandy soil had the blossoms eaten and the insects were spreading into the portions of the vineyard situated on the heavier soil. Mr. Louis Bourne, owner of the vineyard, stated that these insects had destroyed most of the crop the two years previous. The damage in Mr. Bourne's vineyard was most severe in 1908 and 1909. In 1909 two acres of Niagaras produced $2.35 worth of grapes, while his Concords gave him very small returns.

EXPERIMENTS IN 1909 AND 1910 TO CONTROL THE ROSE-CHAFER.

It can readily be seen that although this insect occupied an area of less than twenty acres, it demanded attention because of the damage it was doing and the fact that no economical method of control was known. It is true that hand picking and spraying with arsenical poisons had been recommended, but neither was of any avail when there were literally hundreds of thousands of beetles in the vineyard. Study of the insect was also demanded because of the danger of its spreading into other vineyards. It is fortunate that the land surrounding this vineyard for some distance is heavy loam and clay which has assisted materially to confine the pest to the small acreage it now infests. As soon as the infestation was known arrangements were made to spray the vineyard with arsenate of lead and bordeaux mixture with the hope of poisoning the beetles. It was scarcely hoped to save the 1909 crop owing to the vast amount of destruction wrought by the beetles before the spraying was done; but destruction of females before their eggs were laid would be a step toward protecting the crop of 1910. Accordingly the vineyard was sprayed on June 28, 1909. A traction sprayer was used which would maintain a pressure of 100 to 125 pounds per square inch and which had six Vermorel nozzles. The spray used was bordeaux mixture (8–8–100 formula) and six pounds of arsenate of lead. The weather was fair and the entire vineyard was very thoroughly sprayed, using 100 gallons of spray mixture per acre.

It was noted that the portion of the vineyard sprayed in the forenoon had scarcely any beetles on the vines in the afternoon, while the unsprayed portion had many of the insects feeding on the vines. The following day all the sprayed portions of the vineyard had very few beetles while the unsprayed portions (checks) had many. It was also seen that the rose-chafers had migrated to the sumac blossoms, and we believed that the bordeaux mixture was distasteful to the beetles, as several entomologists had claimed before, and so felt sure that if the material were applied just when the rose-chafers were attacking the vines it would save the blossoms. Our experiments of 1910 proved that bordeaux

mixture does not drive the beetles unless they are about ready to leave the vines, when it will hasten their departure. As mentioned above, the beetles leave the vines after feeding on them for nearly two weeks and go to other food plants, especially the sumac, which begins to blossom about a week and a half later than the grape. This is a natural habit of the beetles, and our spraying in 1909 apparently hastened their departure slightly, since the beetles did not leave the (check) unsprayed rows as soon as those sprayed.

The crop was carefully weighed but no gain was made on the sprayed plats over the unsprayed plats. This could hardly be expected since the vineyard was sprayed after the beetles had done their damage.

In planning the various experiments for 1910, it was not considered advisable to rely entirely upon the bordeaux mixture to "drive" the insects off the vines, but it was thought well to try other methods of control.

Fall plowing.—Plowing the land in the fall and at least once during the winter in order to expose the larvæ to the action of the cold was thought worthy of trial. A section of land was plowed in the fall, but the severity of the winter prevented the second plowing. By covering the soil with trap cages it was possible to learn, approximately, the numbers of beetles on tilled and untilled land. It was found that fall plowing had a slight effect in reducing the number of beetles, but not such as would make economical the adoption of the practice for killing the rose-chafer.

Cultivation when the insect is in the pupal stage.—Another method of control is the one that has been practiced with some degree of success against the root-worm; namely, cultivation during the latter part of May and the first half of June to kill the pupæ. The vineyard was plowed May 25th, 26th, 27th, 28th, and a strip about fifty feet wide in the grass field to the east of the vineyard was plowed June 11th. By means of the trap cages the emergence on the cultivated land was compared with the emergence on the untilled land.

June 2d Mr. Bourne harrowed the vineyard, using a spring

tooth harrow set deep. An examination of the soil showed many pupæ crushed by the harrow. This operation was repeated June 7th and on June 11th, making three thorough harrowings. The cage on the untilled land showed twice as many beetles emerged as the cage on the tilled land until June 20th, when the cage on untilled land was disturbed and many of the beetles escaped. While the exact record was interfered with the results show a great gain up to the time the cage was opened. Then the examination of the soil showed that many of the beetles were killed as pupæ, so we can safely conclude that cultivation during the pupal stage is a means of greatly reducing the number of insects.

Spraying.— The rose-chafer is considered by all entomologists a difficult insect to kill. Attempts were made to kill it with arsenate of lead but this usually resulted in failure when the insects were very numerous although for moderate infestation it was useful.

It will be noted on page 511 that one of the aims in experimenting with barium chloride was to learn whether it would kill insects quicker than arsenic. In the case of the grape flea-beetle it was found that when glucose was mixed with arsenate of lead the beetles died in about four hours' time. Having learned this, it was decided to try it against the rose-chafer.* It was necessary to know whether the bordeaux mixture and arsenate of lead or bordeaux alone would "drive" the insects from the sprayed vines. Again, the lime-sulphur solution has been recommended as a fungicide to be used in place of the bordeaux mixture, and it was desired to know whether it would have any repellent effect on the rose-chafer. In order to secure data on the value of these various materials in the hope of finding a mixture that would save the vineyard, it was sprayed as shown in Fig. 7 on June 21 just as the rose-chafers were coming forth in great numbers. All the material was applied with a traction sprayer, using about 100 gallons per

* Since making the experiments with arsenate of lead and glucose on the grape flea-beetle and the rose chafer, I have learned that L. R. Taft, Consulting Horticulturist Mich. Agr. Exp. Station, has been using molasses and arsenate of lead for the control of the rose-chafer for several years. He used from six to ten pounds of arsenate of lead and a half gallon of cheap molasses to one hundred gallons of water. The results of his experiments were published in The 48th Ann. Rept. St. Bd. of Agr. of Mich. (1909) p. 157, but I did not learn of the fact until seeing an abstract of it in the *Experiment Station Record* (22:659, 660). This number came to my address a short time after the second spraying for the rose-chafer. I have followed Mr. Taft's method, only increasing the amount of molasses in spraying for the root-worm which is given elsewhere in this bulletin. —The Author.

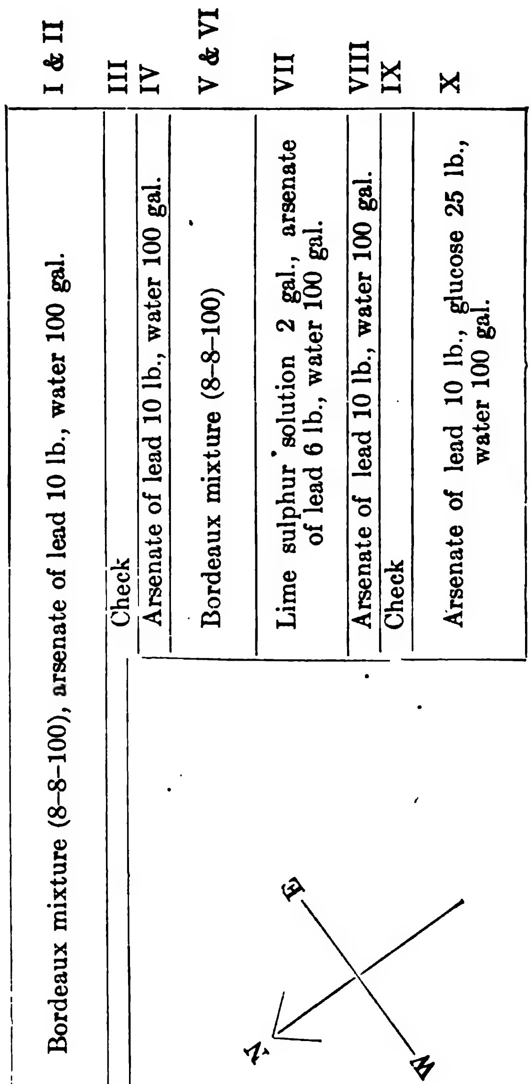


FIG. 7.—DIAGRAM OF BOURNE VINEYARD AS SPRAYED JUNE 21, 1910.

acre, applied with three Vermorel nozzles to a side and at a pressure of from 100 to 125 lbs. per square inch. The vineyard was carefully watched during the week following the spraying and the following facts noted:

1. The bordeaux mixture either alone or with the arsenate of lead had no driving effect on the beetles. The beetles fed on the sprayed foliage as much as on the unsprayed foliage.

2. With bordeaux mixture and arsenate of lead a number of beetles were destroyed by the end of the week but much damage was done to the blossoms before the beetles were killed.

3. Arsenate of lead alone killed the beetles in about the same time as when used with the bordeaux mixture.

4. The lime-sulphur solution did not repel the rose-chafer and, owing to a smaller amount of arsenate of lead used, the beetles did not appear to suffer in the least from it. The lime-sulphur solution in addition burned the foliage.

5. The arsenate of lead and glucose killed the beetles by the following day and the vines were practically free from rose-chafers during the week. It was a very common thing to find the dead beetles clinging to the leaves and blossom clusters. Very few blossoms were eaten.

It thus appeared that at last a remedy had been found and that it would be advisable to spray the entire vineyard with this mixture in order to save the fruit. However, lest any premature opinions might be formed, it was decided to spray the vineyard again on June 28, using some of the same materials as in the first spraying but not treating as many rows, the remaining rows being sprayed with arsenate of lead and glucose. This is shown in Fig. 6 and Table VI.

The grapes were picked in September and October and careful account was made of the weight of the crop from the various plats. These are shown in the accompanying table. Yield per acre has been computed on the basis of 605 vines to an acre. The cost of spraying is that of materials only. The labor required depends on the proximity of the water supply. With water close at hand two men and a team of horses should spray about ten acres a day.

TABLE VI.—EFFECT OF VARIOUS SPRAY MATERIALS ON ROSE-CHAFER.

Plat.	MATERIALS USED.	Date.	Variety.	Number of vines.	Yield of plat.	Yield per vine.	Yield per acre.	Cost* of spraying acre.	Value of crop per acre.	Gain† per acre from spraying.	Gain‡ per acre from spraying.	Gain§ per acre from spraying.
					Lbs.	Lbs.	Lbs.					
I	Bordeaux mixture, 8-8-100, arsenate of lead, 10 lbs.,	June 21										
	Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal.	" 28	Concord	596	2,621	4.4	2,662	$3 27	$53 24	$28 19	.....	......
II	Bordeaux mixture, 8-8-100, arsenate of lead, 10 lbs....	June 21 and 28	do	193	882	4.5	2,722	3 04	54 44	29 62	.....	......
IIIa	Not sprayed..............	....	do	95	168	1.8	1,089	.....	21 78	.....	.....	......
IIIb	Not sprayed..............	....	Niagara	94	196	2.1	1,271	.....	25 42	.....	.....	......
IV	Arsenate of lead, 10 lbs., water, 100 gal...........	June 21 and 28	do	94	427	4.5	2,722	2 00	54 44	27 02	$33 08	$30 05
V	Bordeaux mixture, 8-8-100..	June 21 and 28	do	96	112	1.2	726	1 04	14 52	—11 94	—5 88	— 8 91
VI	Bordeaux mixture, 8-8-100, arsenate of lead, 10 lbs...	June 21										
	Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal.	" 28	do	185	476	2.6	1,573	3 27	31 46	2 77	8 83	5 80
VII	Lime sulphur (32° Beaumé), 1 gal., water, 50 gal., arsenate of lead, 6 lbs...........	June 21 and 28	do	331	668	2.0	1,210	1 84	24 20	—3 06	3 00	—0 02
VIII	Arsenate of lead, 10 lbs., water, 100 gal...........	June 21 and 28	do	144	329	2.3	1,392	2 00	27 84	0 42	6 48	3 45
IX	Not sprayed..............	....	do	89	147	1.6	968	.....	19 36	.....	.....	......
X	Arsenate of lead, 10 lbs., glucose, 25 lbs., water, 100 gal	June 21 and 28	do	170	1,186	7.0	4,235	3 50	84 70	55 78	61 84	58 81

* The cost of spraying is computed, estimating the various spraying materials at the following prices per pound: Copper sulphate 6 cts., lime one-half ct., arsenate of lead 10 cts., glucose 3 cts., lime-sulphur solution 10 cts. per gallon. The cost of labor, horse hire and wear on the machine are not included.

† Plats I and II are each compared with Plat IIIa. Plats IV-VIII and X compared with Plat IIIb.

‡ Plats IV-VIII and X compared with Plat IX.

§ Plats IV-VIII and X compared with the average of Plats IIIb and IX.

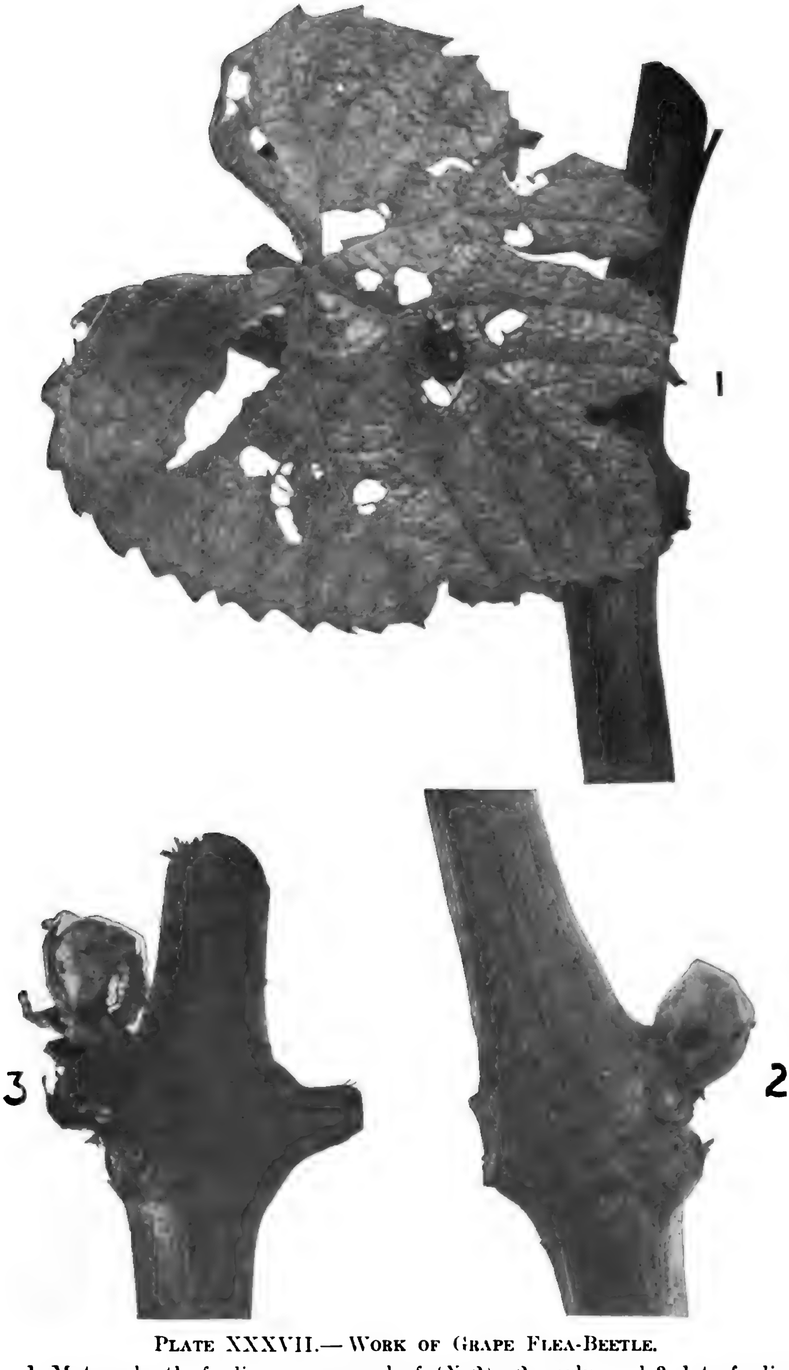


Plate XXXVII.— Work of Grape Flea-Beetle.

1, Mature beetle feeding on young leaf (X 2); 2, early, and 3, late feeding of beetles on grape buds (X 3).

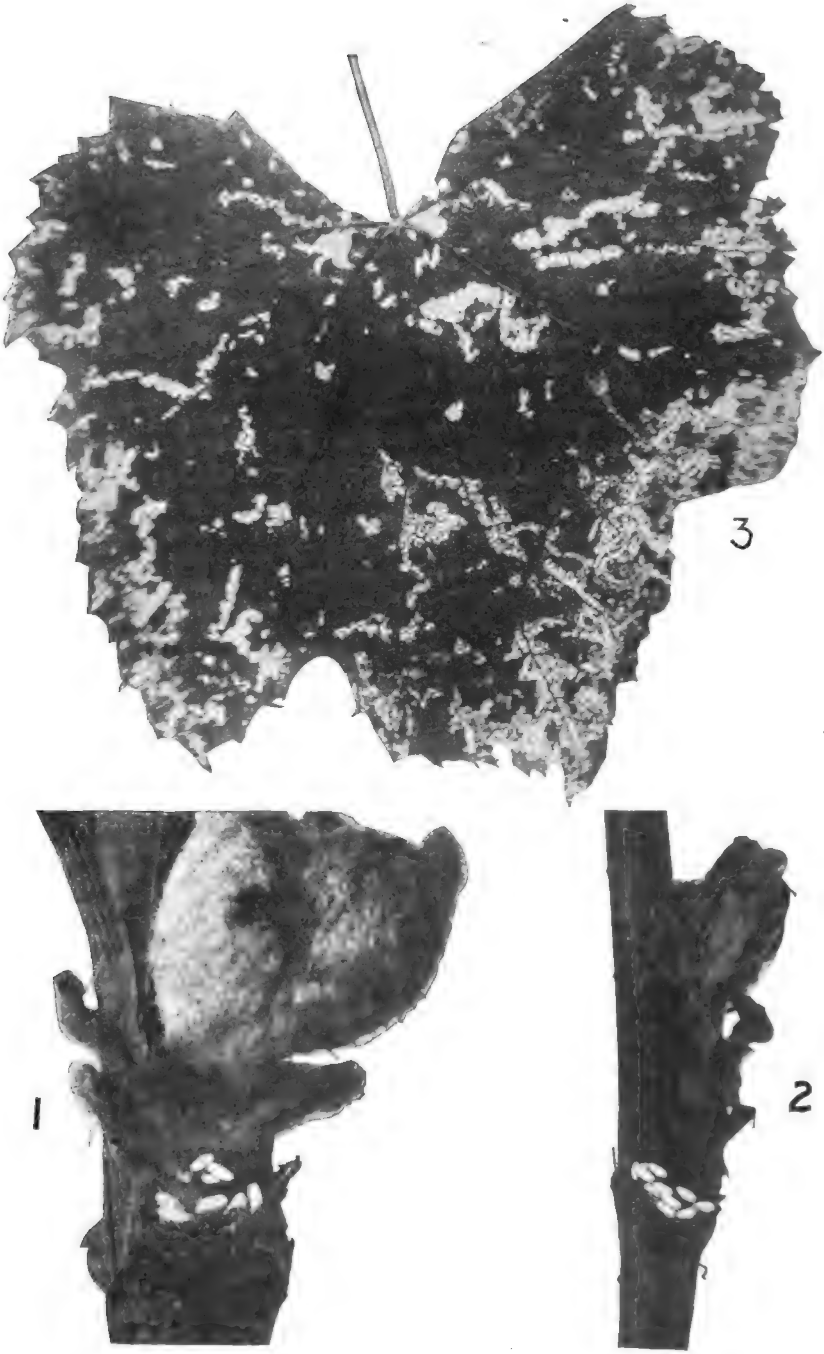


Plate XXXVIII.— Eggs Near Grape Buds (1 and 2) and Work of Larvæ (3) of Grape Flea-Beetle.

(1, x 4; 2, x 2; 3, natural size.)

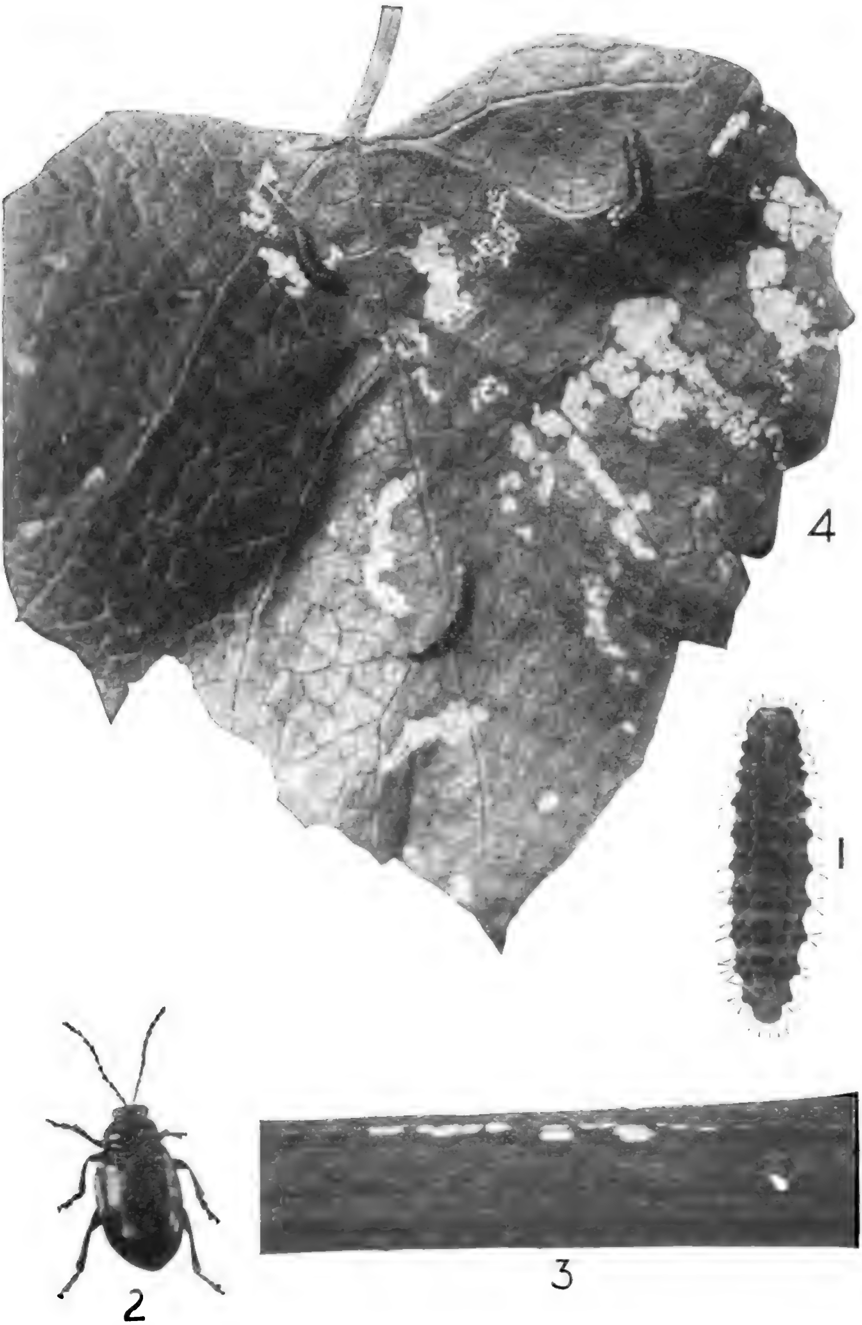


Plate XXXIX.—Some Life Stages of the Grape Flea-Beetle.

1, Larva, (X 5); 2, adult, (X 4); 3, eggs under bark, (X 4); 4, larvæ feeding on leaf (X 2).

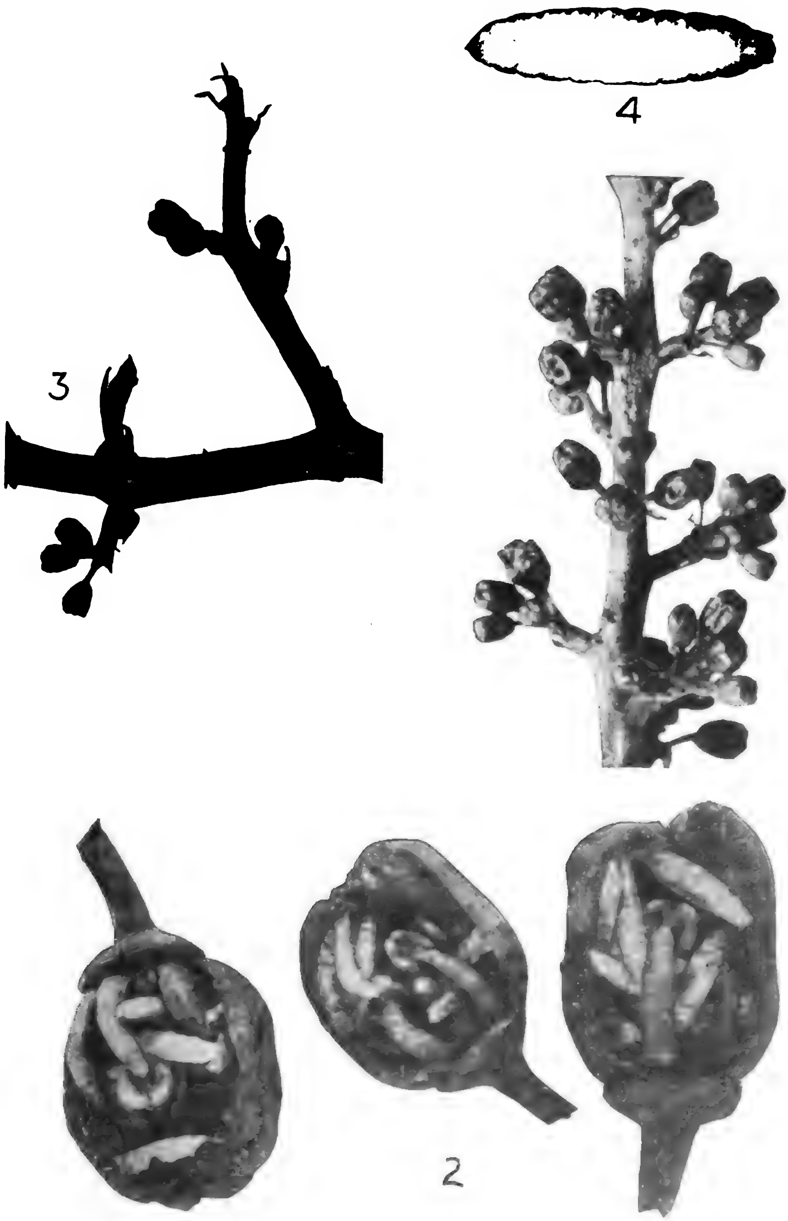


Plate XL.—Larvæ and Work of Grape-Blossom Midge.

1. Blossom buds of grape, swollen buds injured by midge, (X 2); 2, injured buds with midge larvæ, (X 8): 3, destruction of buds by midge, (X 2); 4, larva of grape-blossom midge, (X 20).

(2 from photograph by M. V. Slingerland.)

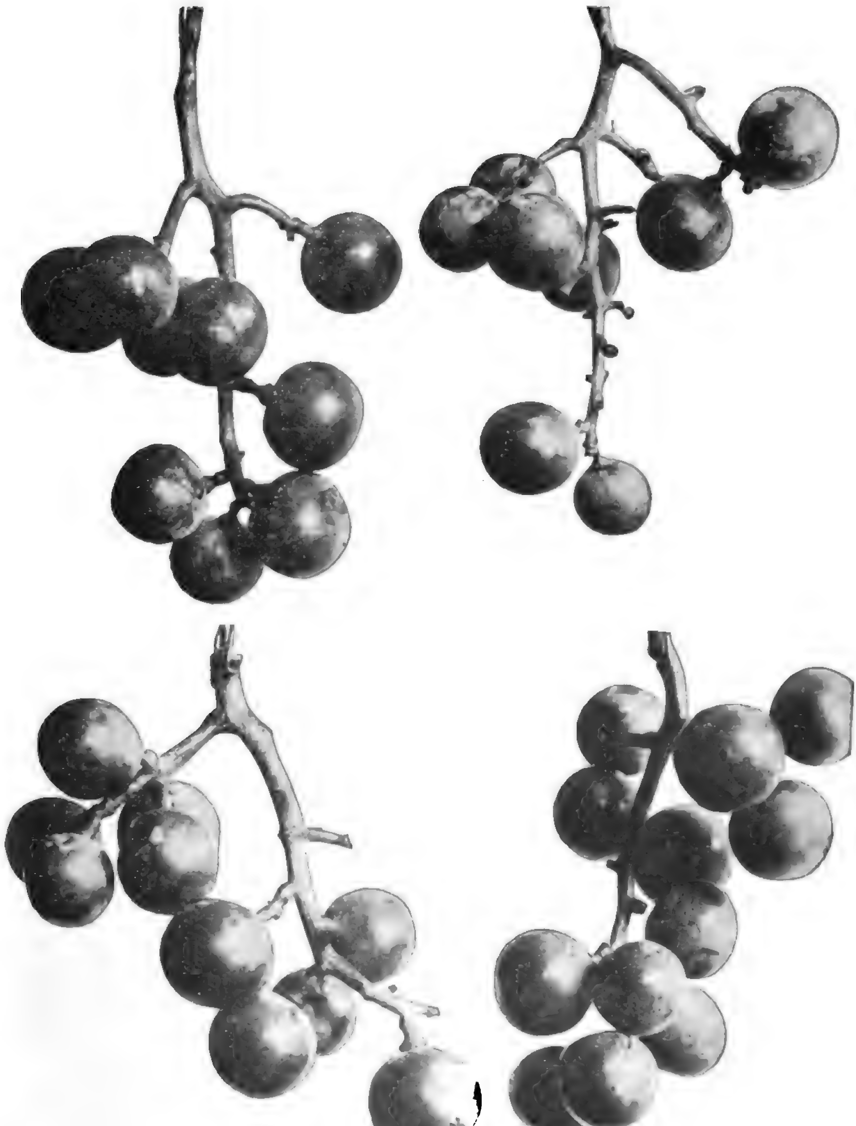


Plate XLI.— Effect on Grape Clusters of Work of Grape-Blossom Midge.

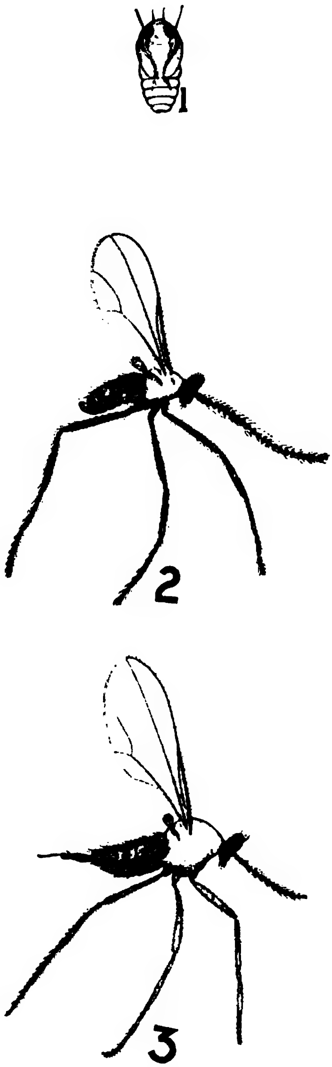


PLATE XLII.—PUPA (1), ADULT MALE (2), AND ADULT FEMALE (3) OF GRAPE-BLOSSOM MIDGE.

(Enlarged 16 diameters.)

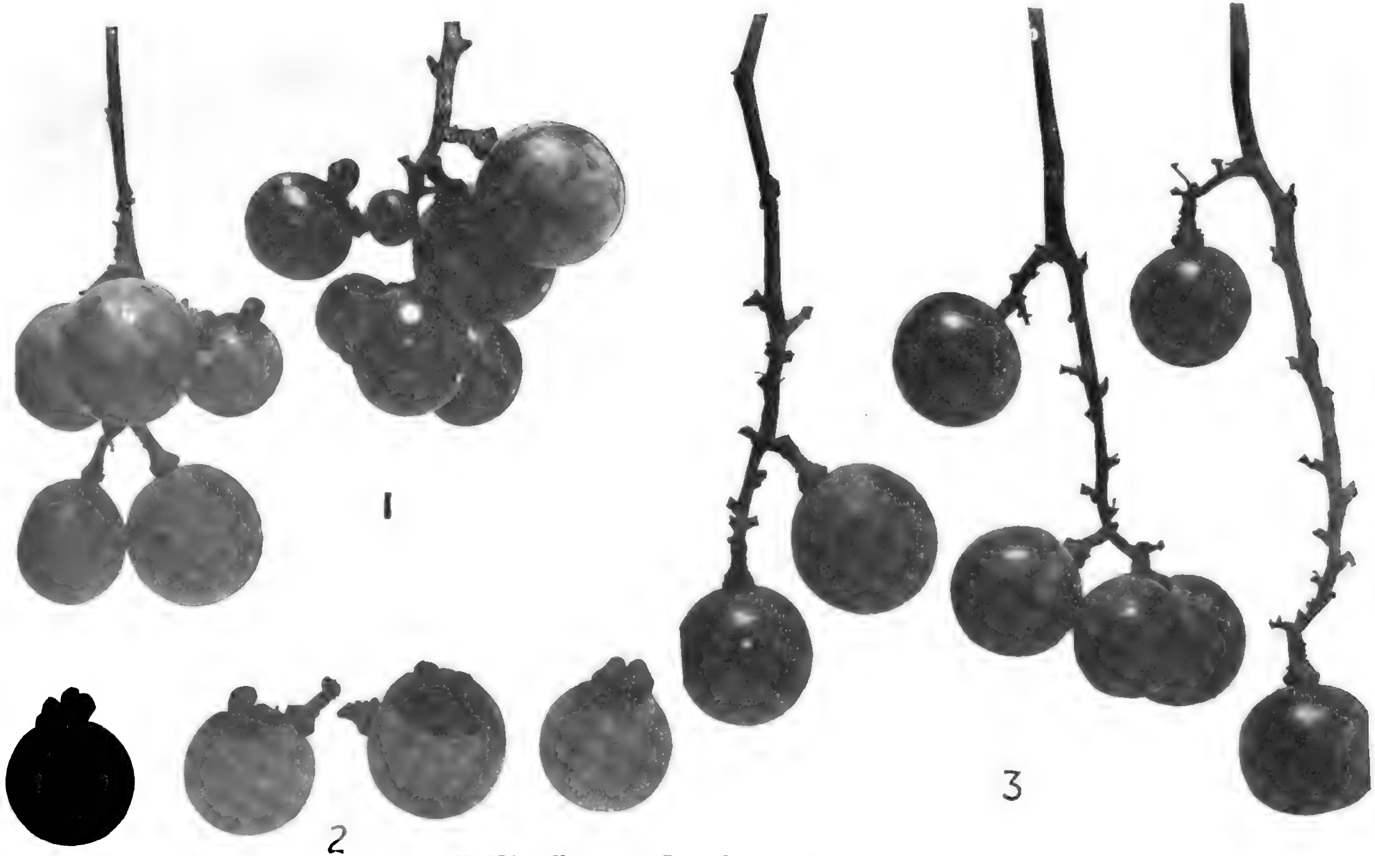


Plate XLIII.—Effect of Rose-Chafer Work on Grapes.
1 and 2, Protrusion of seeds due to beetles feeding on young fruits; 3, imperfect clusters from destruction of blossoms by beetles.

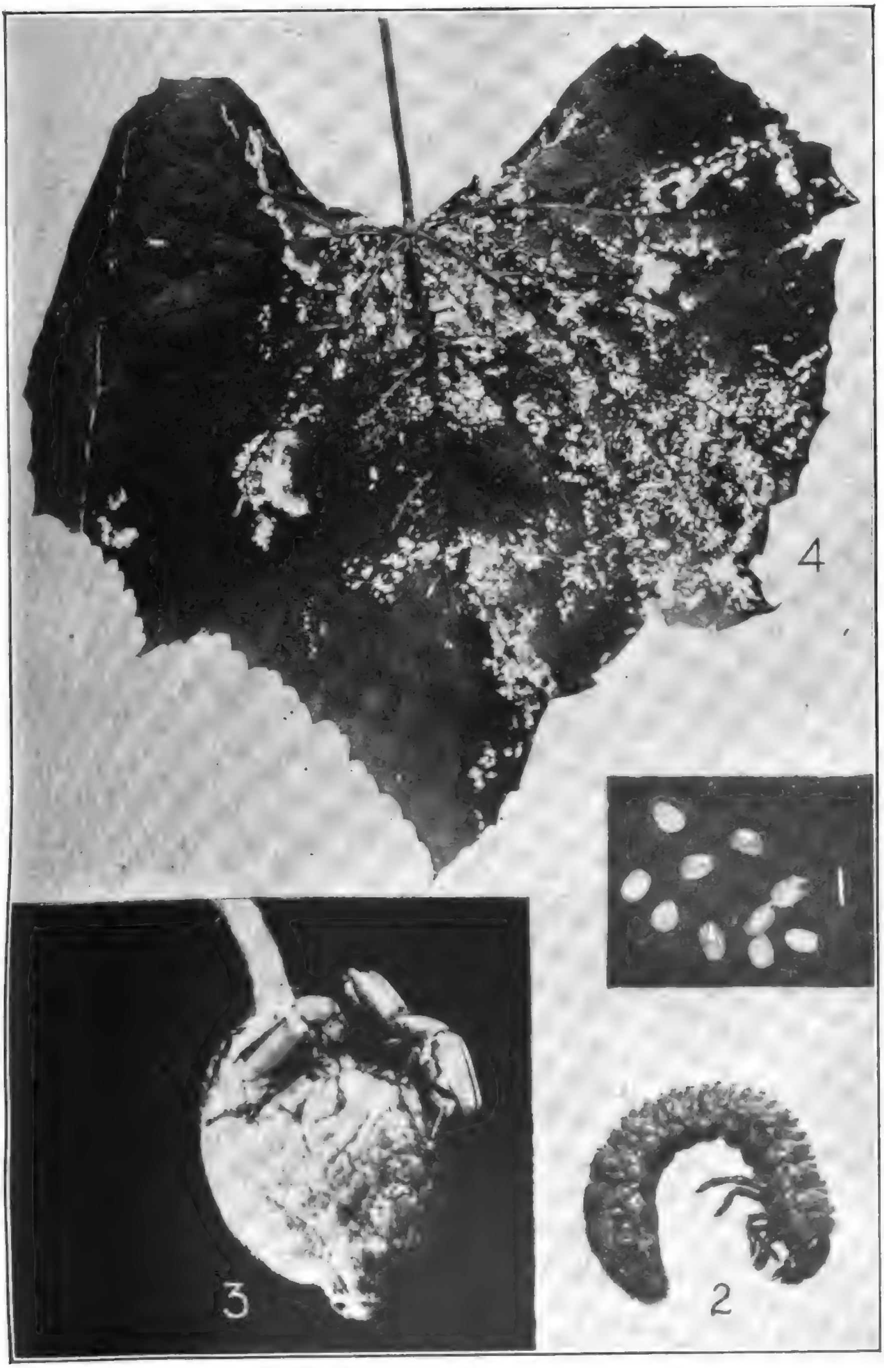


Plate XLIV.— Some Life Stages and Work of Rose-Chafer.

1, Eggs, (X 12); 2, larvæ, (X 4); 3, beetles feeding, (X 1½); 4, work on leaf.

(3 from photograph by P. J. Parrott.)

Plate XLV.— Effect of Control of Rose-Chafer on Yield of Grapes.

Yields of (1) unsprayed row; (2) row sprayed with arsenate of lead alone; (3) row sprayed with arsenate of lead and glucose.

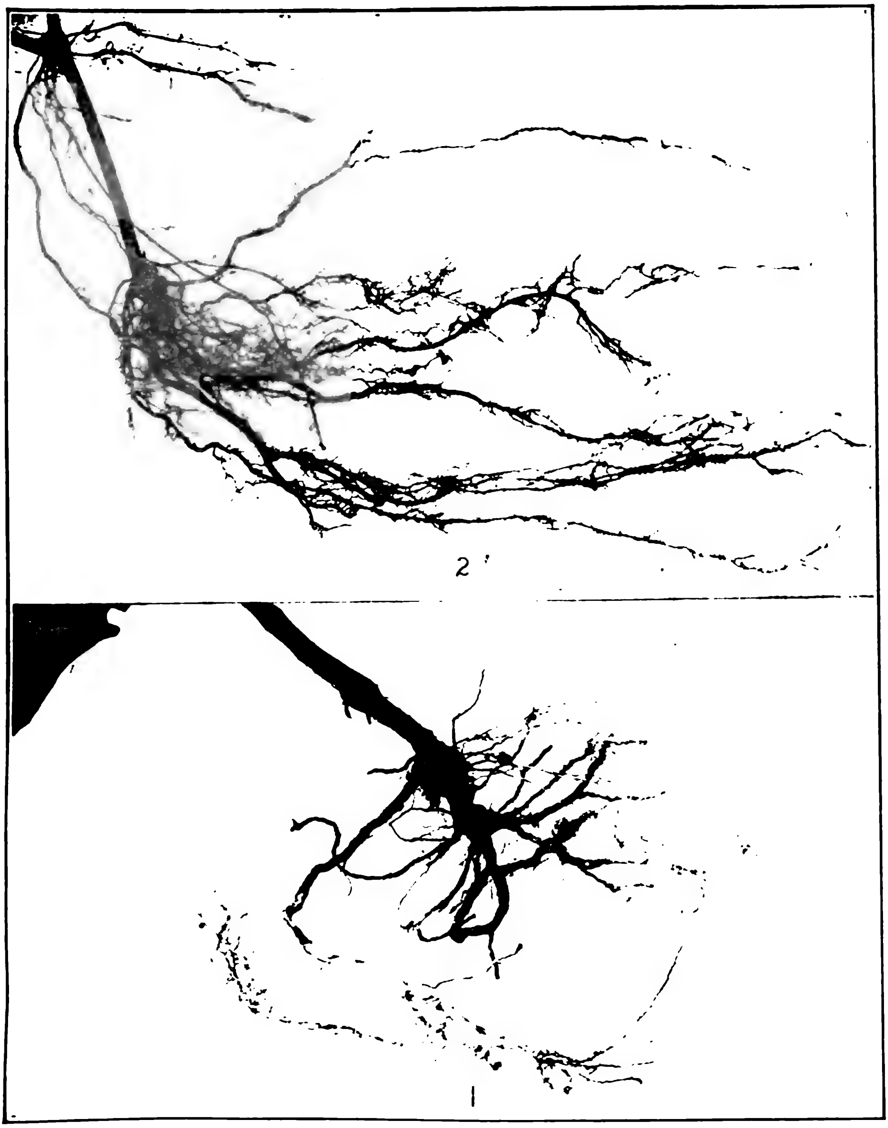


PLATE XLVI.—GRAPE ROOTS (1) INJURED BY GRAPE ROOT-WORM AND (2) HEALTHY.

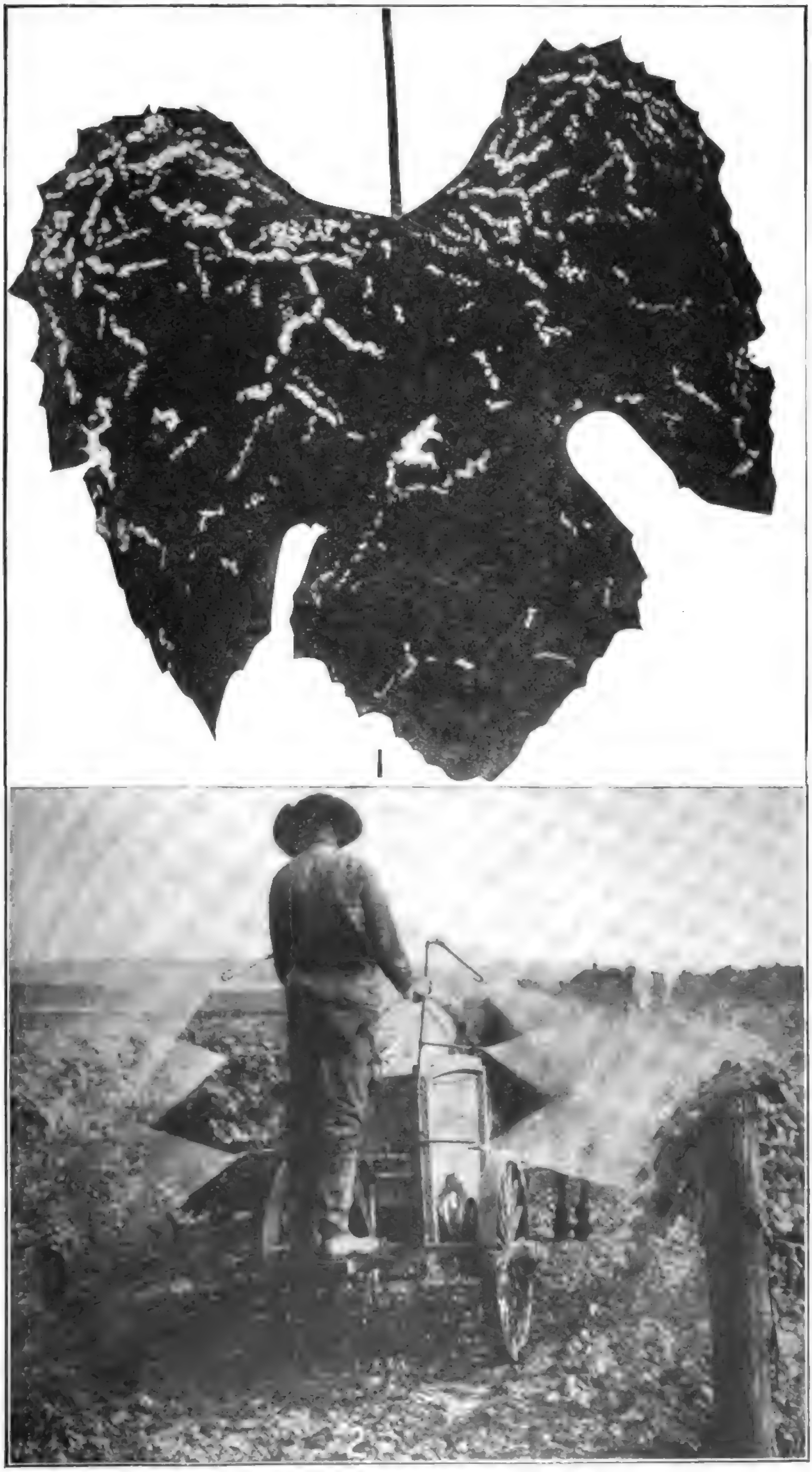


PLATE XLVII.—1. GRAPE LEAF, INJURED BY GRAPE ROOT-WORM BEETLES.
2. SPRAYING FOR GRAPE ROOT-WORM.

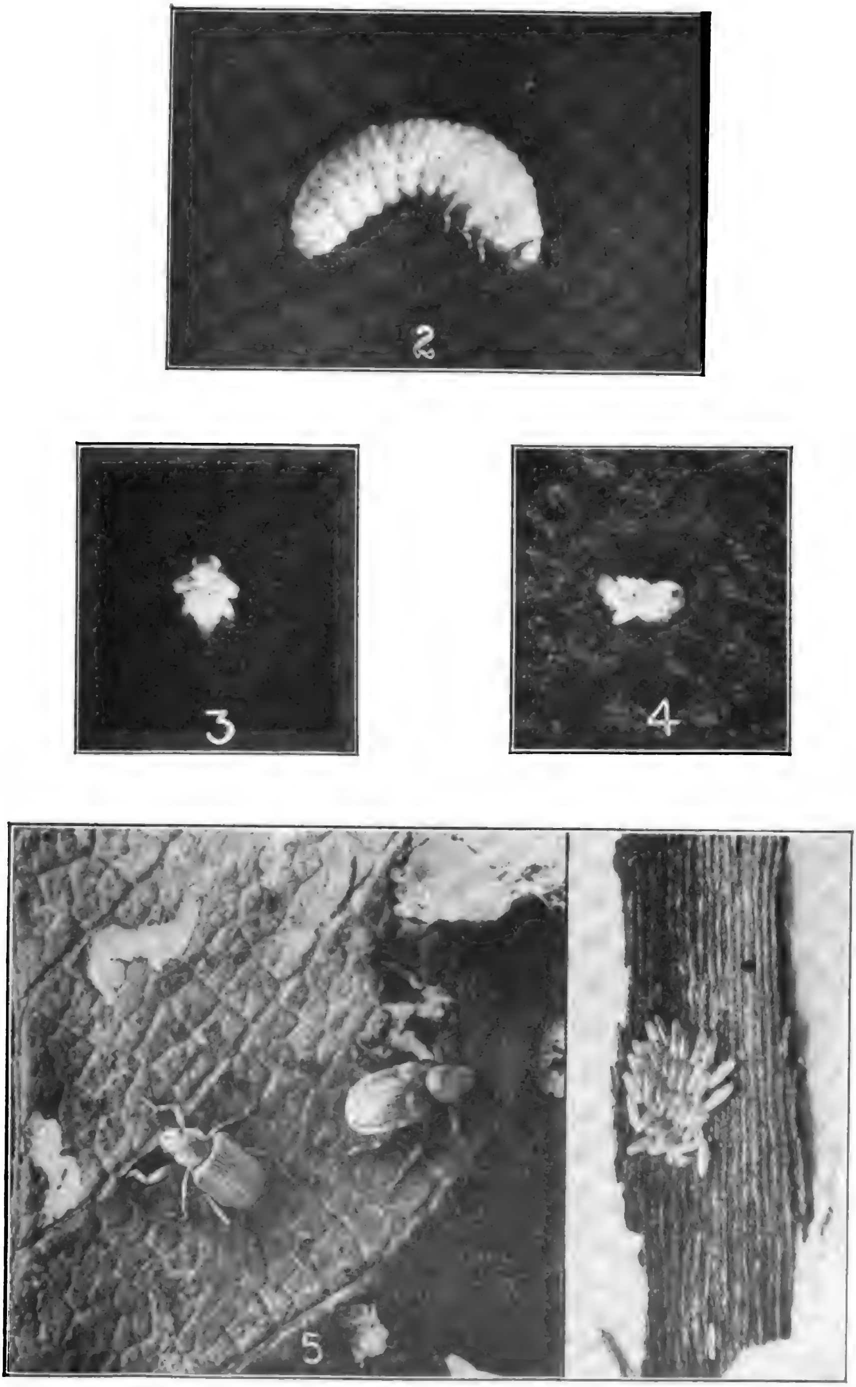


PLATE XLVIII.— LIFE STAGES OF GRAPE ROOT-WORM.

1, Eggs, (X 4); 2, larva, (X 5); 3, ventral view of pupa, (X 1½); 4, pupa in cell, (X 1½); 5, adult beetles feeding on leaf, (X 3).

(5 from photograph by M. V. Slingerland.)

PLATE XLIX.—LIFE STAGES OF GRAPE LEAF-HOPPER.

1, Eggs; 2, nymphs, with two cast skins; 3, different stages of nymphs; 4, adult, and cast skin (1-4, enlarged); 5, infested leaf.

(From photographs by M. V. Slingerland.)

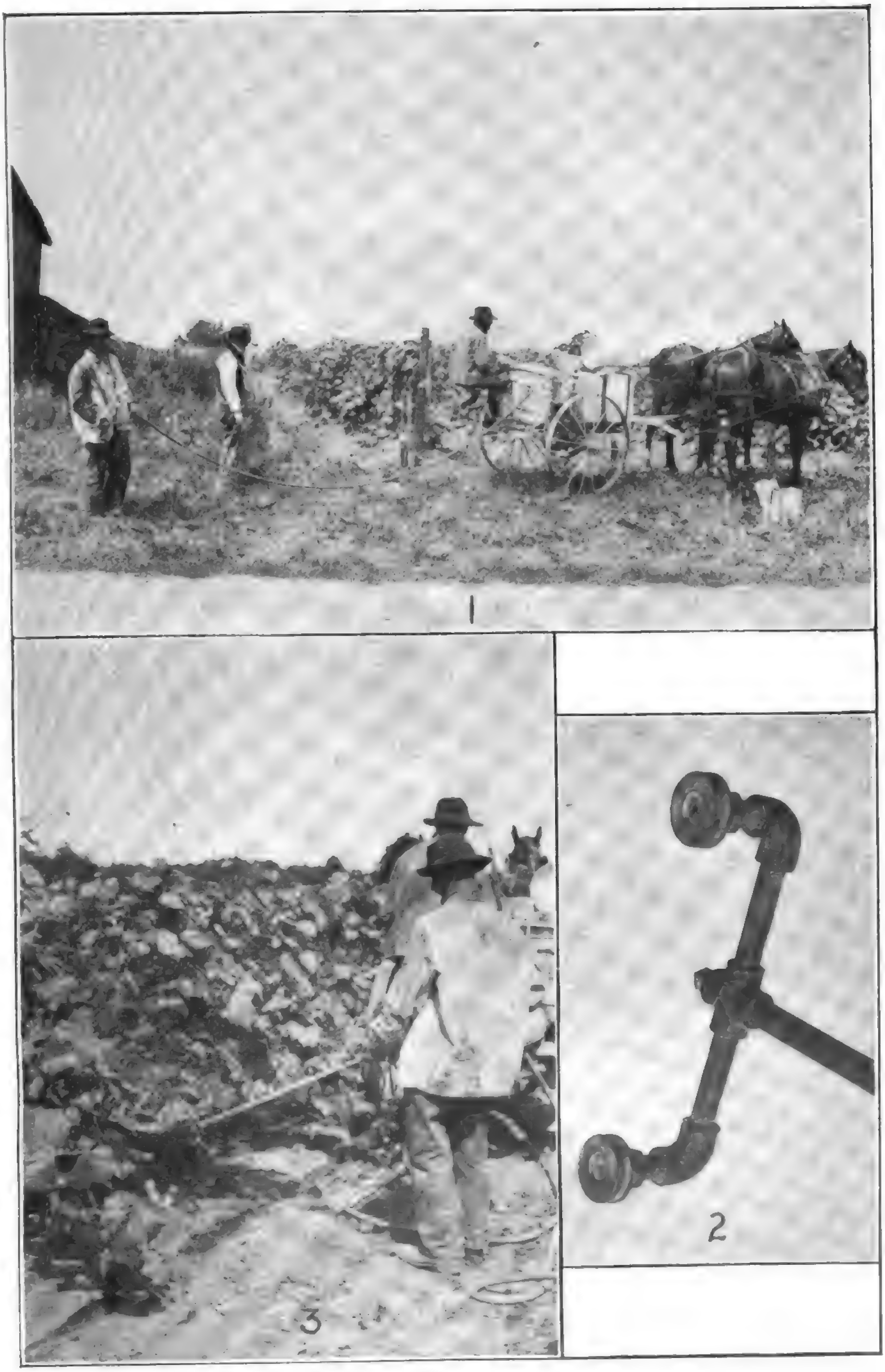


PLATE L.— SPRAYING FOR GRAPE LEAF-HOPPER.
1, Outfit; 2, arrangement of nozzles; 3, at work with the outfit.

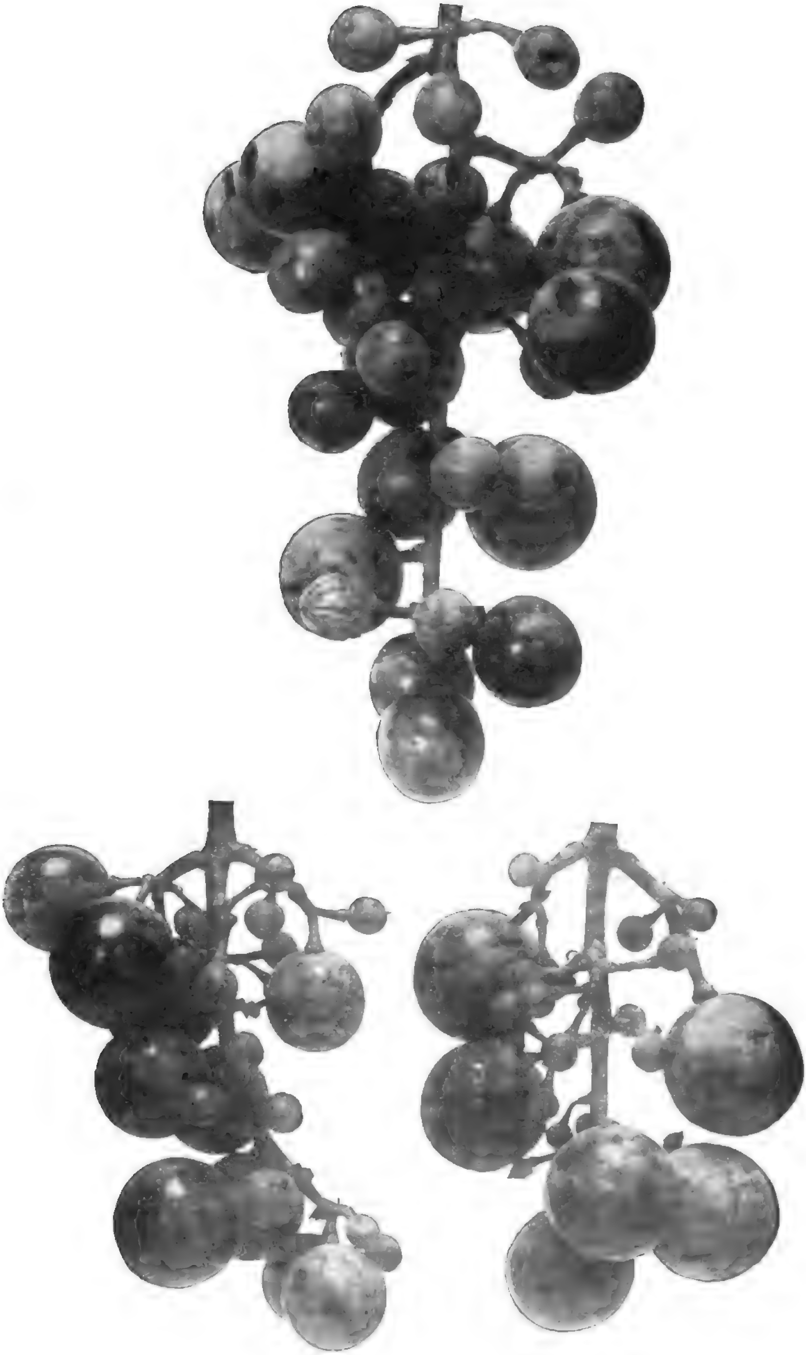


PLATE LI.— GRAPES INJURED BY LIME-SULPHUR SPRAY.

When the grapes were picked the yield of a row containing forty-five vines from each of the plats VIII, IX and X was kept separate and a photograph was taken of the yield from each row (Plate XLV). Fig. 1 shows the yield from the row of plat IX (unsprayed) and shows ten and one-half eight-pound baskets. Fig. 2 shows the yield from the row of plat VIII (sprayed with arsenate of lead alone) and shows sixteen eight-pound baskets of grapes. Fig. 3 shows the yield from the row from plat X and shows forty-two eight-pound baskets of grapes. In selecting the rows it was thought best to select the row adjoining plat IX both on plat VIII and X as this would give vines that were nearly uniform as regards vigor.

In experimental work there are many factors to be considered. The vines should be of the same variety and of the same age and vigor and they should be on a uniform soil and should be treated alike regarding cultivation and fertilization. Then, too, the vines should be uniformly infested.

These conditions have been met to a large extent in these experiments, since it is extremely difficult to find all these conditions in one vineyard. If an experiment does not show a decided gain over the check plat there is reason to believe that the difference may be due to variation in the soil or in the vigor of the plants. On Plat IV the yield is nearly double that on Plat VIII, yet the vines on the two plats are of the same variety and same age, are on similar soils and were sprayed with the same material. It is believed that this is due to the difference in infestation which was observed. Just why the insects should show this preference for certain plats is not known. The other plats were rather uniform in their infestation except I and X which were worst infested, since the beetles, migrating from the grass fields, attacked these plats first, while the larvæ in the soil were as numerous here as in the other plats.

RECOMMENDATIONS.

There are two distinct methods of reducing the numbers of the rose-chafer: cultivation and spraying.

When the larvæ are in cultivated soil belonging to the owner of the vineyard the number of adults may be decreased by spraying and by cultivating the land when the insects are in the pupal stage. Experiments seem to show that at least half of the pupæ may be destroyed by three harrowings made from the last week in May to the middle of June. When the chafers are in the soil of the vineyard this is an economical method because the frequent cultivation at this time should be a usual practice. It is important to watch the time the pupæ first appear and the depth they are in the ground. It may happen that during a very dry spring they would be so deep as not to be reached by a harrow, but during an average year there will be little trouble in this respect. If grass fields with sandy soil surround the vineyard it will be necessary to watch these, for they will furnish excellent feeding places for the larvæ. They can be plowed and harrowed the same as the vineyard and if planted to corn need not be any extra expense to the vineyardist since the cultivation will help that crop.

With all the favorable results obtained by killing the pupæ by cultivation, this method is not claimed to be a sure cure but is recommended as an aid to the other methods of destroying the rose-chafer.

Spraying.— This will perhaps become the most efficient remedy for this troublesome pest. If the insects come from soil belonging to persons not interested in the growing of grapes and who suffer no injury from the beetles, there is no other recourse than to kill the beetles when they are feeding on the vines and even if many of the pupæ are killed by cultural methods we must prevent destruction by those remaining through spraying.

The results of the author and those of other entomologists seem to prove very clearly that either the bordeaux mixture alone or in combination with the arsenate of lead is not to be relied upon when the beetles are very abundant although some successes have been reported where the chafers were not very numerous. The results of Prof. Taft in Michigan with arsenate of lead and molasses and our

results with arsenate of lead and glucose at Westfield where the rose-chafers were very abundant would indicate that the most practical remedy to recommend is: 10 pounds of arsenate of lead, 25 pounds of confectioners' glucose (or a gallon of molasses), and 100 gallons of water.

In making these recommendations we desire to say that this mixture may not be all that we desire as a remedy and further experiments may prove that it must be modified or discarded entirely but with the present experience we believe it to be the best remedy known. More trials with this mixture for the rose-chafer will be made if the insects are found in numbers that will give a chance for experimentation. Until we learn more regarding the exact amount of arsenate of lead to use we advise at least 10 pounds to each 100 gallons of water.

The material should be applied as soon as the beetles first appear on the vines. Every effort should be made to prevent the insect getting a foothold in the vicinity of vineyards.

THE GRAPE ROOT-WORM.

Fidia viticida Walsh.

ORDER **Coleoptera** FAMILY **Chrysomelidæ**

INTRODUCTION.

The grape root-worm is the most destructive pest in the Chautauqua and Erie grape region and has done much damage to vineyards during the last ten or fifteen years. The larvæ feed unseen on the roots of the grape, so that it often happens that their injurious work is not noticed until the vineyard is ruined. The insect has been found very difficult to control although many experiments have been made to learn the most practicable method of combating the pest. The efforts during the past two summers have been directed more to experiments for the control of the insect than to a detailed study of its life history. This was found necessary owing to the vast amount of damage already done to Chautauqua

county vineyards and, also, because the more important phases of its life history are known.

ECONOMIC IMPORTANCE.

This insect has been the cause of hundreds of thousands of dollars of loss in Ohio, Pennsylvania and New York. For more than twenty years this foe of the vine has laid its tax upon the grape growers. During periods of its abundance hundreds of vineyards may be seen with many of the vines dead and the remainder of the plantings in very poor condition. This insect can be controlled economically only when in the adult stage and feeding on the vine. As the greatest care must be used in the application of the sprays to obtain reasonably satisfactory results, growers generally have had an up-hill fight. Because of their failures to secure efficient protection for their vineyards many of them have practically stopped trying to combat the pest. This neglect has resulted in allowing the root-worm to injure many acres of fine vineyards, especially during periods when these insects have been very numerous. The general decline in Chautauqua county vineyards has been attributed entirely to the root-worm. However, other factors must be taken into account before we assign the different agencies definite rank as to destructiveness. The grape root-worm is, undoubtedly, a very important factor in the decline of these vineyards.

HISTORY.

B. D. Walsh[1] described this species and gave us the first account of its injury. The insect has appeared in literature for nearly a century under other names. The life history of the insect was first described by Prof. F. M. Webster,[2] who found it injuring grapes in Ohio. Additional facts regarding its habits and methods of control were given by Prof. M. V. Slingerland[3] of Cornell University

[1] Walsh, B. D. *Pract. Ent.* 2:87–88. 1866.

[2] Webster, F. M. Cinc. Soc. Nat. Hist. 17:159–169. 1894. Ohio Agr. Exp. Sta. Bul. No. 62. 1895.

[3] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 184:21–32. 1900; Slingerland, M. V. & Craig, J. Cornell Agr. Exp. Sta. Bul. 208. 1902; Slingerland, M. V. & Johnson, F. Cornell Agr. Exp. Sta. Bul. 224. 1904.

and Dr. E. P. Felt, State Entomologist of New York,[4] both of whom made a number of experiments in Chautauqua county. The most recent and the most extensive work on the life history of the root-worm and methods for its control has been done at North East, Pa., by Fred Johnson and A. G. Hammar.[5] The insect has been mentioned in the writings of many other entomologists, but the foregoing references to literature deal with the more important contributions to the life history and methods of control.

ORIGIN AND DISTRIBUTION.

The grape root-worm is an American insect and according to Johnson and Hammar (Fig. 8) has been found in the following states: Arkansas, Connecticut, Delaware, Illinois, Indiana, Indian Territory, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, Maryland, Mississippi, Nebraska, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Texas, Virginia and West Virginia. One curious fact about the history of the distribution in vineyards on the south shore of Lake Erie is that the insect was first found in injurious numbers in Ohio near Cleveland in 1893 and was next detected in injurious numbers in the vineyards of Erie county, Pa., about 1898. A little later it was noticed infesting the vineyards in the western part of Chautauqua county. In 1900 Prof. Slingerland reported it damaging vineyards near Ripley. During 1901 and 1902 the beetles were causing losses as far east as Brocton. Serious outbreaks occurred in 1906, 1907 and 1908, and the severely infested area was extended eastward to Sheridan. During 1909 and 1910 several vineyards near Irving were found badly damaged by the pest although in 1909 the beetles were very scarce in other parts of the county. In 1910 many vineyards from State Line to Irving again showed the beetles in great abundance. Thus there would appear to have been an eastward spread of the insect in this region similar to the well known migration of the Colorado potato-beetle (*Leptinotarsa decemlineata*).

[4] Felt, E. P. N. Y. State Mus. Bul. 53. 1902; Felt, E. P. N. Y. State Mus. Bul. 59. 1902; Felt. E. P. N. Y. State Mus. Bul. 72. 1903.

[5] Johnson, F. and Hammar, A. G. U. S. Dept. Agr. Bur. Ent. Bul. 89. 1910.

However, the fact that the Fidia is found as far east as Massachusetts and Connecticut would seem to indicate that this eastward migration of this species is more apparent than real. The

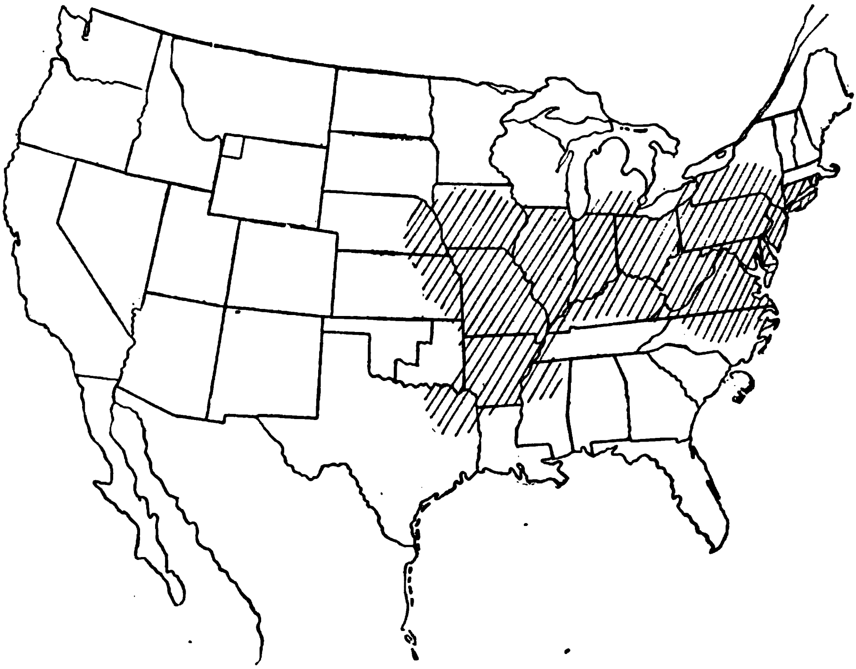


FIG. 8.— DISTRIBUTION OF THE GRAPE ROOT-WORM.
(After Johnson and Hammar.)

insect no doubt has been in the vineyards for a long time but did not attract attention until it became of great importance within the last ten years.

INFLUENCE OF SOIL ON DISTRIBUTION IN CHAUTAUQUA COUNTY.

The character of the soil in which the insect is most abundant has always been a mooted question. Diverse claims are made regarding the amount of infestation and injury to vines by the grape

root-worm on various soils. During the summer and fall of 1910 a special effort was made to throw some light on this question.

Soil samples were secured by driving a soil auger to a depth of three feet, in order to determine the nature of the soil and subsoil in vineyards located about Fredonia and Lamberton. Drainage conditions in each vineyard were noted.

The number of root-worms present was determined by digging about the roots of the vines. The condition of the vines, and the character of the cultivation were also taken into account. The history of the vineyard was also secured. From the studies made we have learned the following facts:

(1) The root-worm is found in injurious numbers in all kinds of soil at various times. Vineyards on gravel, sandy loam, shale loam, heavy clay loam or clay soils have been found that were practically ruined by the root-worm.

(2) Certain vineyards are much more seriously infested than others adjoining them and situated on the same kind of soil. These anomalies we are unable to explain at the present time.

(3) Practically every vineyard has a greater or less infestation of grape root-worm. This is true in almost every vineyard in northern Chautauqua county. For a man to say that he has no root-worm in his vineyard usually means that he is ignorant of the fact or that the insect has not as yet done much damage.

(4) Soil conditions are important factors in the amount of injury that the Fidia can do to the vines. Often two vineyards situated near each other and having the same amount of infestation but on different soils will have vines entirely different as regards vigor and yield. When a vineyard is on a soil poorly adapted for grapes the number of roots that the vine will grow is small. The few root-worms present feed on these and thus cause more injury to the vines than the same number of root-worms on the roots of vines on soils adapted to the growing of grapes where a large mass of roots are put forth. The vines in the poorly adapted soil are not so resistant to the phylloxera, or root-louse, and in consequence the few remaining roots have many nodules thus further decreasing the power of the vines to take up sustenance from the soil.

(5) The principal soil conditions affecting the growth of the vine are poor drainage, lack of moisture, and lack of humus.

Poor drainage.— This condition obtains in many vineyards, especially on the more level soils such as the clay and the heavy loam, but it is also true of much of the hillside soil. On the clay and clay loam soils where drainage is poor the vines are especially unthrifty, but clay land that is well drained, either naturally or artificially, has some of the finest vineyards in the belt. However, much of the clay and clay-loam land is poorly drained, which has made the average vineyard on such land a poor-paying proposition. On the hillsides the soil is known as Dunkirk-shale loam and is underlain with shale. This comes near to the surface in many places. Often the uneven weathering of this rock has formed areas which are locally known as " kettles " from which the water slowly drains, or produces areas which are level for a short distance. Such land when planted to grapes often is ridged by cultivation so that the water stands in large pools in the vineyard long after rains. In all such poorly drained areas it will be noticed that the vines make an unsatisfactory growth.

Lack of moisture.— This condition was found in several vineyards where a sandy soil at a depth of a foot or more had formed a compact mass which might be called " hard pan." This condition prevented the soil moisture from ascending and thus the vines were deprived of moisture, especially during dry spells. Here the vines put forth so few roots that root-worms would soon devour them.

Lack of humus.— Several vineyards were found which showed a decided lack of humus and here the poorly developed vines were severely injured by root-worm. Now the remedies for these conditions belong to the province of the soil specialist and the horticulturist and therefore are not discussed. They are being studied by the horticultural department of this Station. The idea which the author wishes to emphasize is that the extent of injury by the root-worm is largely determined by soil conditions.

(6) The root-worm problem cannot be solved entirely by im-

proving soil conditions, but when this insect appears in destructive numbers it must be combated by spraying.

FOOD PLANTS.

The species of wild grape are undoubtedly the original food plant of the Fidia. It has been found feeding on such wild vines, on Virginia creeper (*Psedera quinquefolia*) and on red bud (*Cercis canadensis*). It feeds on the roots and foliage of cultivated grapes and as yet no variety appears to be entirely immune to its ravages.

CHARACTER AND EXTENT OF INJURY.

The greatest damage to the grape is done by the larva feeding on the roots of the vines. It feeds on the smaller roots and rootlets and when numerous destroys most of them (Plate XLVI, fig. 1). If there are many larvæ on the roots they will often feed on the bark of the larger roots, eating furrows into them. The comparison between a vine having the roots destroyed by the larvæ of Fidia and one with healthy roots is shown in Plate XLVI, figs. 1 and 2. Vines having the roots destroyed cannot produce well. The injury to the roots does not make itself evident on the growth of the vine until the following season. The owner may not be aware of the presence of the pest and the following spring the vines are either dead or dying, this condition being often attributed to winter injury.

The adult beetle feeds on the leaves of the grape and the markings are characteristic, being of a chain-like appearance (Plate XLVII, fig. 1).

DESCRIPTION

Egg.— The eggs of the grape root-worm are small yellowish bodies measuring 1.1 mm. (about .04 inch) in length and about .4 mm. (about .016 inch) in thickness (Plate XLVIII, fig. 1). They are cylindrical with the ends somewhat globular. They are usually curved owing to the stress produced by the bark under which they are laid.

Larva.— The full grown larva varies in length from 8 to 10 mm. (.3–.4 in.) It is much whiter than the larva of the rose-chafer and also broader in proportion to its length (Plate XLVIII, fig. 2). The spiracles are light brown. The head and thoracic shield are yellowish brown. The clypeus, or upper lip, is light brown with a dark margin which has a number of short spines. The mandibles are brown with black tips. The antennæ consist of four short segments. The legs are white, with the tarsi light brown, and are thickly set with setæ.

The body has many setæ but these are not nearly so numerous as the setæ of the rose-chafer larva.

Pupa.— The pupa (Plate XLVIII, figs. 3 and 4) is slightly shorter than the larva and is white. There are hook-like processes on the distal ends of the femora which are prominent as are the similar hooks on the posterior part of the body. The entire body has a number of setæ, or hairs. On the head and posterior segment are found a number of spines and setæ which support the pupa in its cell.

Adult.— The adult beetle (Plate XLVIII, fig. 5) is of a reddish brown color and is covered with short gray hairs which give the insect a grayish appearance. The head is closely covered with small pits known as punctures and there are fine striations which run lengthwise. The clypeus and mandibles are shining black, the former having a number of yellow setæ. The antennæ consist of eleven segments and are yellowish-brown, with many short setæ.

The thorax is finely punctured and is wider behind. The elytra, or wing covers, are striated, with punctures occurring in the striæ. The legs are brown and the feet slightly darker. Length, about one-fourth inch.

SEASONAL HISTORY.

Emergence.— The adult beetles appear during the latter part of June or the beginning of July. At Fredonia in 1909 the first beetles emerged in the cages on June 28. They were first found in the vineyards on gravel soil on June 30, but on clay soil and on the hillsides near Prospect Station not until a week later, July 6, when they had reached their maximum number on gravel soil.

In 1910 the appearance of the first beetles in the cages and in the vineyards on gravel soil was on July 5, with the maximum emergence nearly two weeks later. At Prospect Station the first beetles appeared about July 15, 1910, and the maximum number did not appear until July 22.

Feeding habits.— The adults usually do not begin feeding until a day after emergence. They feed on the leaves by tearing small portions of the tissue with their mandibles. After feeding for a while the adults remain in hiding, and during the cooler portions of the day are generally to be found on the canes, especially near the top wire.

Egg deposition.— After mating the female begins depositing eggs under the bark on the canes. Egg deposition during 1910 began July 15 in vineyards on the gravel soils and continued until the latter part of August, since females were found with eggs as late as August 20. The egg-laying period thus begins from ten days to a week after emergence and occupies a period of a month and a half.

No cage records were secured regarding the number of eggs a female beetle lays, but Johnson and Hammar found that, in their studies, a female laid an average of 112 eggs and the egg-laying occupied over two months.

Egg.— The eggs hatch, on an average, in two weeks, the exact length of time depending on weather conditions.

Larva.— The small larva after hatching crawls about on the cane and soon falls to the ground where it immediately burrows into the soil. It works its way to the roots of the vines on which it feeds. It grows rapidly and often reaches full size by November. If it does not attain its full growth by that time it usually does so during the following spring. In several instances Johnson and Hammar found that the larvæ lived until the second summer before changing to pupæ.

During the month of November the larvæ burrow down into the soil to a distance of about a foot where they form cells and thus pass the winter. In the early part of May they leave these larval

chambers and return to the roots where they may feed a short time and then change to pupæ during the early part of June. The larvæ that do not reach full growth by winter feed a somewhat longer period and may not change to pupæ until nearly the first of July. The normal larval stage is about ten months.

Pupa.— The larvæ when ready to pupate burrow to a depth of several inches (the exact depth varies according to the amount of moisture in the soil) and twist their bodies about to form rough pupal cells in which they change to pupæ (Plate XLVIII, fig. 4). In 1909 the first larvæ changed to pupæ about June 11 but the majority did not change until June 15 and the pupal stage lasted a little over two weeks on the average. During 1910, some larvæ changed to pupæ June 20 but the majority did not change until nearly the end of June.

SUMMARY OF LIFE HISTORY.

The adults emerge during the latter part of June and the early part of July. After feeding for nearly two weeks on the leaves of the grape, they mate, and the females begin egg deposition which may extend over a period of two months. The eggs hatch in about two weeks and the young larvæ fall to the ground, burrowing to the roots where they feed upon the small roots until November. Then they burrow to the depth of a foot or more and form a cell in which they pass the winter. During the early part of May they leave these cells and may feed for a short time on the roots of the grape. The second week of June they begin to form pupal cells and change to pupæ. The pupal existence lasts between two and three weeks.

STATUS OF ROOT-WORM CONTROL.

The use of arsenate of lead to control the root-worm has been found to be the most efficient and also the most economical method of combating this insect. The formula that appears to be used the most extensively is six pounds of the poison either in 100 gallons of water or with the same amount of bordeaux mix-

ture. There has been some question regarding the effectiveness of this poison on the adults since some experimenters have secured excellent results while others have been only partially successful. These differences in results may have been due to varying amounts of arsenic in the various brands of arsenate of lead or to the manner of applying the spray material. However these do not explain all the discrepancies in the results of various investigators and at present there appears to be some other factor that is in part responsible for these varying results obtained by spraying.

Since 1900 the grape growers have as a rule shown very little enthusiasm in spraying for this pest, and at present only a small percentage of them make systematic efforts to combat it. The chief reason for this neglect is that spraying in many vineyards has not seemed to be profitable. On the other hand there are a number of growers who have been very successful in protecting their vineyards and recommend spraying as the most efficient means of combating this pest.

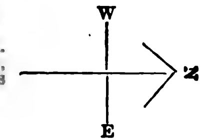
EXPERIMENTS WITH THE GRAPE ROOT-WORM.

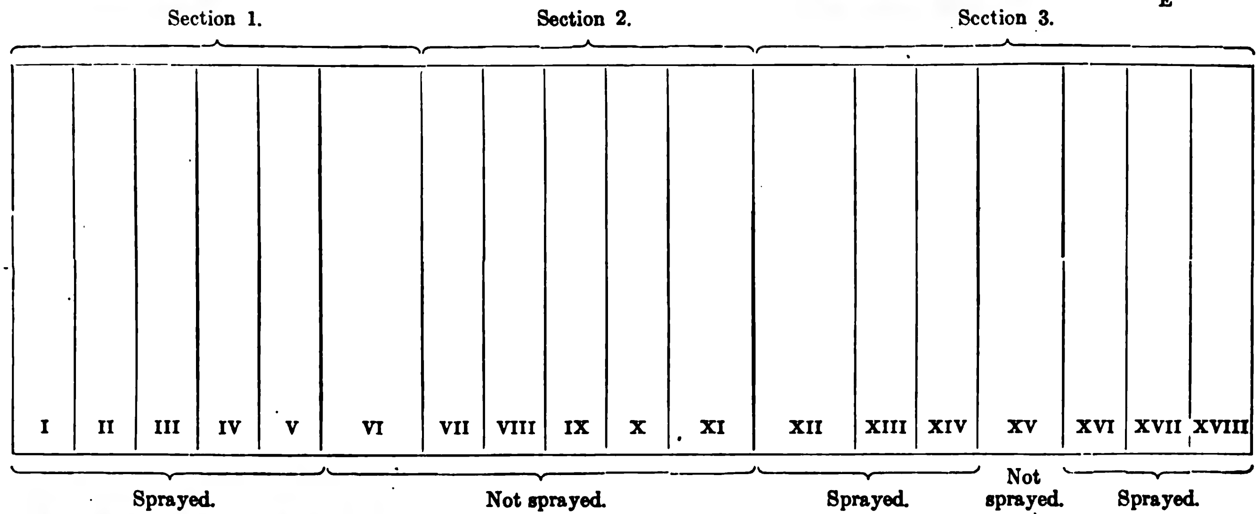
Because growers generally have failed to protect their vineyards the Station has undertaken to determine what are the most practicable methods of controlling the root-worm. Experiments are now being conducted in the vineyards of James Barnes, Prospect Station, and Sherman J. Lowell, Fredonia. The conditions of the experiments and the progress of the work are described as follows:

Plat I. Manure, sprayed.
II. Manure and lime, sprayed.
III Complete fertilizer, sprayed.
IV. Phosphoric acid, potash and lime, with nitrogenous cover crop, sprayed.
V. No fertilizer, sprayed.
VI. No fertilizer.

Plat VII. Manure.
VIII. Manure and lime.
IX. Complete fertilizer.
X. Phosphoric acid, potash, lime with nitrogenous cover crop.
XI. No fertilizer.
XII. No fertilizer, sprayed.

Plat XIII. Manure, sprayed.
XIV. Manure and lime, sprayed.
XV. No fertilizer.
XVI. Complete fertilizer, sprayed.
XVII. Phosphoric acid, potash, lime with nitrogenous cover crop, sprayed.
XVIII. No fertilizer, sprayed.





Spray mixture used. Bordeaux mixture (8–8–100) and arsenate of lead 6 lbs.
Manure used at rate of five tons per acre.
Lime used at rate of one ton per acre once every three years.
Complete fertilizer consists per acre of nitrate of soda 100 lbs., dried blood (containing 10 per ct. nitrogen) 560 lbs., acid phosphate 300 lbs., sulphate of potash 200 lbs.
Plats IV, X and XVII fertilized with 300 lbs. acid phosphate, and 200 lbs. sulphate of potash per acre.

FIG. 9.— DIAGRAM OF BARNES VINEYARD AT PROSPECT STATION, N. Y.

PROSPECT STATION EXPERIMENTS.

This vineyard contains five acres of Concord grapes of about twenty years of age. The vines were in a very unsatisfactory condition when the experiments were started, largely because of the ravages of the grape root-worm. The vineyard is located on Dunkirk shale loam, and represents conditions in nearly 3000 acres of vineyards in Chautauqua county. This experiment was undertaken to determine more especially the most efficient and most practicable method of renovating a vineyard that has been severely injured and is still subject to attacks by destructive numbers of the root-worm. The work provided for a series of tests with spraying and the use of fertilizers.

In certain plats various fertilizers are tried both with and without spraying, and in order to learn the value of spraying as compared with the use of fertilizers in restoring a vineyard, certain plats are sprayed and not fertilized. Three check plats are placed so as to have vines that are representative and they are treated exactly as the other plats except they are neither fertilized nor sprayed. The vineyard is divided into eighteen plats as shown in the diagram (Fig. 9). It will be noted that the vineyard is really divided into three sections, of which the first and third are duplicates. The vineyard is not entirely uniform but the vines in the second section are representative of the average conditions of growth and vigor. In the first section the vines are somewhat superior to the average, while those in the third section are slightly below the average. A fair comparison can be made with the plats on the second section by taking the average of the corresponding plats in the first and third sections. Four rows of vines constitute about one-fourth of an acre.

During the summer of 1909, the vineyard was cultivated a number of times and was sprayed twice.

In 1910 the vineyard was fertilized as shown in the diagram and was sprayed only once since this treatment was sufficient to protect the vines from the beetles. The various kinds of fertilizer, as indicated, were used since little is known regarding the proper fer-

tilizer for grapes. The entire vineyard was cultivated a number of times and was sown to a cover crop of oats except three plats which were sown to clover. Bordeaux mixture (8–8–100) to which was added six pounds of arsenate of lead was used and was applied with a geared sprayer having four nozzles to a side and maintaining 100 pounds pressure to the square inch. The object of the experiments is not so much to test the various kinds of fertilizers as to learn whether fertilizing and spraying, or either of these practices alone, is the best and most practicable method of restoring and maintaining the vigor of a vineyard that is injured by the grape root-worm.

Table VII.— Effect of Spraying and Fertilizers on Injury by Grape Root-worm.

Concord Vineyard of James Barnes, (1910), Prospect Station, N. Y.

Plat	SPRAY MATERIAL	Years sprayed	Fertilizer (1910 only)	Number vines	Yield per plat	Yield per vine	Yield per acre
					Lbs.	*Lbs.*	*Lbs.*
I	Bordeaux mixture, 8–8–100; arsenate of lead, 6 lbs.	1909 and 1910....	1¼ tons stable manure	118	390	3.3	1,997
II	do	do	Stable manure, 1¼ tons; lime, ¼ ton..	114	245	2.1	1,271
III	do	do	Complete fertilizer...	98	300	3.0	1,815
IV	do	do	Phosphoric acid, potash and lime......	61	165	2.7	1,634
V	do	do	Not fertilized.......	78	300	3.8	2,300
VI	Not sprayed..................................	....	Not fertilized.......	133	380	2.9	1,755
VII	Bordeaux mixture, arsenate of lead.............	1909, but not 1910.	Stable manure......	96	250	2.6	1,573
VIII	do	do	Stable manure and lime.............	57	200	3.5	2,118
IX	do	do	Complete fertilizer...	109	230	2.1	1,270
X	do	do	Phosphoric acid, potash and lime.....	89	205	2.3	1,392
XI	Not sprayed..................................	....	Not fertilized.......	131	425	3.2	1,936
XII	Arsenate of lead, bordeaux mixture	1909 and 1910....	No fertilizer........	153	200	1.3	787
XIII	do	do	Stable manure......	70	125	1.8	1,089
XIV	do	do	Stable manure and lime.............	96	210	2.2	1,331
XV	Not sprayed..................................	....	No fertilizer........	147	245	1.7	1,029
XVI	Bordeaux mixture, arsenate of lead.............	1909 and 1910....	Complete fertilizer...	111	245	2.2	1,331
XVII	do	do	Phosphoric acid, potash, lime.........	114	350	3.1	1,876
XVIII	do	do	No fertilizer........	118	465	4.0	2,420

The averages are as follows:

	Lbs. per A.
No fertilizer, no spraying, in 1909 or 1910	1,573
No fertilizer, sprayed, in 1909 and 1910	1,835
Stable manure, sprayed in 1909 only	1,573
Stable manure, sprayed in 1909 and 1910	1,543
Stable manure and lime, sprayed in 1909 only	2,118
Stable manure and lime, sprayed in 1909 and 1910	1,301
Phosphoric acid, potash and lime, sprayed in 1909 only	1,392
Phosphoric acid, potash and lime, sprayed in 1909 and 1910	1,755
Complete fertilizer, sprayed in 1909 only	1,270
Complete fertilizer, sprayed in 1909 and 1910	1,523

No comparisons can be made between the yields of the plats treated with the various fertilizers since they require a longer time to show results, but the plats that received no fertilizer and were sprayed (plats V, XII and XVIII) and the plats which received neither spraying nor fertilizer (plats VI, XI, and XV) can be compared since the results of the spraying of 1909 should begin to be apparent in 1910. There was a difference of 262 pounds of grapes per acre in favor of the sprayed plats.

It is aimed to continue the experiments for sufficient time to clearly demonstrate the facts we desire to learn.

FREDONIA EXPERIMENTS.

This series of experiments was started in 1910, in the vineyard of S. J. Lowell. The vineyard was severely infested with the grape root-worm. On June 9, a number of vines were found dead or dying and an examination showed the roots badly eaten by many larvæ. The ground was dug about the vines and the larvæ feeding on three vines were counted. The result was 54, 50 and 30 larvæ for these vines or an average of 45 larvæ per vine.

The parts of the vineyard that were used for experimental purposes consist of three separate sections: the first, consisting of vines about six years of age; the second section consisting largely of vines of about fifteen years of age; the third, consisting of vines nearly twenty years of age. The soil of all the sections is mapped as Dunkirk sandy loam.

TABLE VIII.—EFFECT OF SPRAYING ON INJURY BY GRAPE ROOT-WORM.

VINEYARD OF S J. LOWELL, (1910); FREDONIA, N. Y.: SECTION I.

Plat.	MATERIAL USED.	Date.	Vines used for egg count.	Number of canes.	Total number egg clusters.	Average per vine.	Average per cane.	Total eggs estimated	Average per vine.	Average per cane.	Number of vines in plat.	Yield per plat.	Yield per vine.	Yield per acre. (605 vines.)
I	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	July 7 & 23	...	...	...	...	...	...	...	...	218	1,108	5	3,025
II	Lime sulphur 1½ gals., water 100 gals., arsenate of lead 6 lbs.	"	...	...	...	...	...	...	...	...	260	1,165	4.5	2,723
III	Not sprayed	...	10	16	35	3.5	2.2	812	81.2	50	110	526	4.8	2,904
IV	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	July 7 & 23	10	15	42	4.2	2.8	876	87.6	58.4	288	996	3.5	2,118
V	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	"	10	17	23	2.3	1.3	384	38.4	22.6	278	762	2.8	1,694
	OLDER VINES.													
VI	Mildew experiment	...	...	...	...	...	...	...	...	...	...	...	...	...
VII	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	July 7 & 23	10	30	73	7.3	2.4	1,416	141.6	47.2	470	1,974	4.2	2,541
VIII	Not sprayed	...	10	33	145	14.5	4.4	2,944	294.4	89.2	173	734	4.2	2,541
	SECTION II.													
I	Lime sulphur 1½ gals. to 100 gals. water, arsenate of lead 6 lbs.	July 7 & 23	10	18	53	5.3	3	1,032	103.2	57	193	258	1.3	787
II	Not sprayed	...	10	17	64	6.4	3.8	1,404	140.4	82.6	100	180	1.8	1,089
III	Atomic sulphur and arsenate of lead 5 lbs., water 100 gals.	July 7 & 23	10	15	58	5.8	3.9	1,384	138.4	92.2	44	72	1.7	1,029
IV	Arsenate of lead 6 lbs., glucose 20 lbs., water 100 gals.	"	10	21	49	4.9	2.3	884	88.4	42.1	248	546	2.2	1,331
V	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	"	10	19	18	1.8	.95	228	22.8	12	250	828	3.3	1,997
	SECTION III													
VI	Bordeaux mixture 8-8-100, arsenate of lead 6 lbs.	July 23	20	53	94	4.7	1.8	1,768	88.4	33.4	...	...	...	...
VII	Arsenate of lead 6 lbs., molasses 1 gal., water 100 gals.	"	20	53	149	7.4	2.8	2,908	145.4	54.8	...	...	...	...

The vineyard was sprayed on July 7, using the various mixtures shown in the table. A geared sprayer having four Vermorel nozzles on a side was used. About 100 gallons of mixture was applied to an acre at a pressure from 100 to 125 lbs. per square inch.

At this date the beetles were present on the vines by the thousands and as near as could be learned from observation the infestation was uniform on the three sections. The use of the arsenate of lead and glucose was prompted from the success of this mixture when used for the rose-chafer. The vines were carefully watched during the two weeks following the spraying, but to our chagrin and surprise the beetles appeared to enjoy feeding on the various insecticides and not much depletion in their numbers could be seen. Even the arsenate of lead and the glucose did not appear to kill them.

The vineyard was sprayed again July 23, using the same mixture as in the first spraying, but on noticing that these preparations had little effect on the beetles it was considered advisable to try molasses with the arsenate of lead instead of glucose, as had been done by Prof. Taft for the rose-chafer. Accordingly the vines of section III were sprayed with this mixture and the remaining portion of the section was sprayed with bordeaux mixture and arsenate of lead for comparison. The molasses and arsenate of lead was applied at six o'clock in the evening of the 23d of July.

To facilitate closer observation on the relative values of the various mixtures used, a number of sheets of cheese cloth were placed under vines sprayed with the different materials to catch the dead beetles as they fell to the ground. At 8 A. M. the following day Mr. Lowell found six dead beetles on the sheet under the vines sprayed with the arsenate of lead and molasses but could find none on the sheets under the vines sprayed with other materials. The author was notified of these results by telephone and an examination of the conditions of the vineyard found the facts as given by Mr. Lowell to be correct. On the ground under the vines sprayed with the arsenate of lead and the molasses there were many dead beetles and a very careful search under the vines of the other sec-

tions showed very few specimens. The difference in the number of beetles feeding on the vines on this section was in marked contrast to the number on the vines of the other plats.

As is the usual practice in determining the value of a spray for the grape root-worm the number of egg clusters found on ten or more consecutive vines which represent the average of the plat were counted and the number of eggs for these vines estimated. These figures would seem to indicate how effective the spray was in preventing the female beetles from laying their eggs. A glance at the table will show that the number of eggs was greater on the vines treated with molasses than on the twenty vines in the adjoining plat sprayed with the bordeaux mixture. This is somewhat of a paradox since the vines that had the greatest number of dead beetles had the larger number of eggs deposited upon them. It is not possible to give a satisfactory explanation for these results. The experiment seemed to indicate very plainly that the use of molasses with arsenate of lead is a much more effective treatment for the adults than arsenate of lead alone or in combination with bordeaux mixture. If future experiments substantiate these results it ought to be possible by early and thorough spraying with molasses and arsenate of lead to kill the beetles before they deposit their eggs in any considerable numbers. Our efforts in future experiments will be largely directed to determine if this can be done.

RECOMMENDATIONS.

Cultivation during the time the insect is in the pupal stage.— Cultivation about the roots of the vines with a horse-hoe has been generally recommended, and is practiced by a number of grape growers. By delaying this horse-hoeing until the first two weeks in June, when the root-worm is in the pupal stage, many of the cells are broken and the delicate pupæ thus exposed to the air and sun perish. In limited areas where chickens can be encouraged to follow the team many of the pupæ will be eaten. Blackbirds also relish these insects and should be encouraged to follow the horse-hoe. Birds would render greater assistance if they were better protected and encouraged to nest in the vicinity.

The value of horse-hoeing for destroying the insects varies with soil and weather conditions. Since the insects pupate at a greater depth when the soil is dry than when it is moist, many of the cells are too deep during some seasons to be reached by the horse-hoe. With the most favorable results from this practice, cultivation is only recommended as an aid to spraying in reducing the number of adult beetles that will emerge.

Spraying.— The application of poison when the adults are feeding on the vines is one of the best methods of controlling the insect. Arsenate of lead at the rate of six pounds to 100 gallons of water or bordeaux mixture is recommended. It should be applied first when the beetles begin to feed, which varies from June 18 to July 5, and a second spraying should be given about two weeks after the first.

The experiments of Johnson and Hammar indicate that this mixture will control the insect under favorable conditions. Our experiments during the past season seem to show that one gallon of molasses with six pounds of arsenate of lead and 100 gallons of water will kill many of the beetles, and this combination should be tried in an experimental way in comparison with the above formula. By doing this the grape growers can compare the two mixtures and determine for themselves whether the new spray possesses any advantages over other mixtures for this pest.

THE GRAPE LEAF-HOPPER.

Typhlocyba comes Say.

Order **Hemiptera** Family **Jassidæ**

INTRODUCTION.

The grape leaf-hopper (*Typhlocyba comes* Say), or as it is wrongly called, "thrips," is a common insect in the Chautauqua grape region. Since it has caused serious losses in the past and because it has been considered a difficult insect to control, it has been studied and experiments were made to learn better methods of combating the pest.

HISTORY.

The grape leaf-hopper has been known since 1825, when it was described by Say.[1] Harris[2] in 1841 published a very excellent account of the insect. Gillette[3] in 1898 added a fine contribution on the synonomy of the species. Slingerland[4] in 1904 published a commendable bulletin on the habits and life history of the species and gave the result of experiments for its control. In fact, his methods of combating the leaf-hopper are the most practicable yet devised. The idea of using nozzles adapted to throw the spray on the under side of the leaves is the most recent and the most economical method of applying insecticides for this pest. Quayle[5] in 1908 gave an excellent contribution to our knowledge of the life history of this species in California.

Origin and distribution.— The grape leaf-hopper is an American insect and appears to be found wherever the grape grows. It has caused injury in vineyards on the Atlantic and Pacific coasts and is recorded as far south as Texas and New Mexico.

ECONOMIC IMPORTANCE.

This insect is usually of small economic importance, but during seasons of great abundance it causes extensive loss to the vineyardists. The most recent serious outbreak was in 1901 and 1902, when the vineyards in the western part of the county were seriously infested. Since the insect injures the leaves, these drop from the vines prematurely, thus preventing the ripening of the grapes. The loss to the vineyardists in Chautauqua county for those two years could be counted in thousands of dollars. Since 1902 the insect has appeared only in certain vineyards, and while it has been injurious in these, its numbers in the grape belt as a

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[1] Say, T. *Jour. Acad. Nat. Sci. Phil.* 4: 327. 1825.
[2] Harris, T. W. Insects Injurious to Vegetation. Flint Ed. 228. 1841.
[3] Gillette, C. P. Proc. U. S. Nat. Museum, 20: 759–764. 1898.
[4] Slingerland, M. V. Cornell Agr. Exp. Sta. Bul. 215. 1904.
[5] Quayle, H. J. Cal. Agr. Exp. Sta. Bul. 198. 1908.

whole have not been considered serious. During 1910 the "hopper" has been quite abundant, but the small crop of grapes was not injured. In many places the injury to the vine growth was severe. This will affect the yield on such vines for another year.

Food plants.— The natural food plants in New York are the various species of wild grapes to be found generally distributed throughout the State. Whether it feeds on other plants during spring and fall has not been determined for this State, but Quayle found that in California these insects fed on a large number of species of plants during the winter, spring and fall months. In the east it is known to feed on the Virginia creeper (*Psedera quinquefolia*).

Character and extent of injury.— Vines injured by hoppers for several years have a stunted growth and bear few grapes. Often, one side of a vineyard will have a severe infestation while the other portions are comparatively free from injury. This is especially true where the vineyard adjoins waste land (either brush or woodland or land having high grass remaining over winter). These furnish excellent places for the insects to pass the winter. There is a marked contrast between the vines that are badly infested and those that suffer no injury, since the infested vines are dwarfed and stunted, and this affects the size of the crop the following year. The damage is caused by the leaf-hopper puncturing the epidermis of the leaf on the under side and sucking the sap. The portion of the leaf around the puncture turns yellow and dies; and when the insects are numerous the entire leaf becomes yellow, dies, and often drops to the ground before the grapes are ripe. Since the leaf is the manufacturing part of the plant and the place where the inorganic matter taken in by the roots and the carbon dioxide taken from the air are changed into the various organic substances which constitute plant tissues, it is easy to see why injuries to leaves prevent the development of the wood or the fruit. When the vines are heavily loaded the grapes do not ripen thoroughly. Thus the injury results in a loss in the size of the crop and a loss in the quality of the fruit.

DESCRIPTION OF THE INSECT.

Egg.— The eggs (Plate XLIX, fig. 1) are partially transparent, slightly curved or kidney shaped and are between .7 mm. and .8 mm. (about .03 in.) in length and from .2 mm. to .3 mm. (about .01 in.) in width.

Nymph.— The nymphs (Plate XLIX, figs. 2 and 3) resemble the adults in general shape, but lack wings. They have wing pads which increase in size with each moult. They are of a yellowish-white color and have red eyes. Slingerland says they have five distinct stages and require thirty to thirty-three days to pass through their moults.

Adult.— The adult insect (Plate XLIX, fig. 4) has a general color of yellow which is variously marked with black or red stripes and irregular areas. The great variety of color patterns has resulted in the insect being described as a new species a number of times. It is now believed these are varietal differences.

This insect belongs to the Hemiptera or true bugs and obtains its food by piercing the plant tissues with its long proboscis and sucking the sap.

SEASONAL HISTORY.

The adults may be found on the under sides of the leaves of the grape rather early in the spring soon after the leaves have unfolded (Plate XLIX, fig. 5). Here they live by piercing the lower epidermis of the leaf with their sharp proboscides. They are exceedingly active and will fly when slightly disturbed. The adults mate and about the middle of June the female begins egg laying. This she accomplishes by piercing the skin of the leaf with her long, sharp ovipositor and inserting the eggs within the tissue.

The eggs hatch during the first and second week of July although in 1910 a few eggs hatched as late as July 20th. Many of the nymphs reach the adult stage by August 1st, but the majority do not reach full development until later. They remain on the vines until autumn when they seek places to hibernate. Brush piles, waste land, grass, leaves which have collected in

fence corners and in fact almost any place that will shelter them will be found to harbor the hoppers. In the spring when the leaves of the grape appear they pass from these hiding places to the grape leaves again.

EXPERIMENTS IN SPRAYING FOR GRAPE LEAF-HOPPER.

During 1909 the number of leaf-hoppers was not such as would cause alarm. There were a few vineyards, however, that were severely infested but the author did not learn of them in time to undertake spraying operations against the insects. In 1910 experiments to determine methods of combating the leaf-hopper were commenced in three vineyards, comprising twenty-six acres, near Silver Creek. The conditions of these vineyards and the principal details of the spraying operations are as follows:

SACKETT VINEYARD.

This vineyard, owned by Mr. M. J. Sackett, consisted of two sections of Concord grapes of different ages. The vines were badly infested in 1909 and 1910, and in addition were severely injured by the root-worm. One section of the vineyard was sprayed July 11th but, owing to trouble with the machine, the other section was not sprayed until July 14th. The contact insecticides used were resin fish-oil soap, lime-sulphur solution testing 32° Beaumé, and Black-Leaf Tobacco-Extract.

Resin fish-oil soap.— The use of whale-oil and fish-oil soaps has been recommended since 1904 when Slingerland secured good results with them at the rate of 10 pounds of soap to 100 gallons of water. However, there have been complaints by certain grape-growers that when the soap is used—especially in a very strong solution — there is a tendency for the soap to cling to the berries and stems of the clusters and thus decrease the market value of the grapes. This complaint is made particularly during a season when there is little rain from the middle of July until the middle of October. The chief objects in using the resin fish-oil soap were to learn whether it would cause trouble and whether

the method of spraying was at fault when certain vineyardists had failed to control the leaf-hopper by using this material.

In order to attack the root-worm and the leaf-hopper at the same time, 10 pounds of the resin fish-oil soap was added to 100 gallons of bordeaux mixture with 6 pounds of arsenate of lead. The vines were thoroughly sprayed on July 11th and were carefully watched during the two weeks following the spraying. Very few of the nymphs were killed by the treatment. Leaves and fruit were much injured by the leaf-hoppers and in this respect differed very little from the unsprayed (check) vines.

Black-Leaf Tobacco Extract.—Owing to the very good reports regarding various nicotine products on different sucking insects a very thorough test was given this mixture. The concentrated extract is guaranteed to contain 2.7 per ct. nicotine, and when one gallon is diluted with 65 gallons of water the solution contains about 1/20 of 1 per ct. nicotine. The first strength tried against the leaf-hoppers was at the rate of 1 gallon of the tobacco extract to 65 gallons of water, and arsenate of lead was used at the rate of 10 pounds per 100 gallons of mixture to kill the root-worm. Another plat was sprayed using the same proportion of arsenate of lead and tobacco extract but 20 pounds of glucose was added to each 100 gallons of the mixture as the addition of this material was believed to be useful in killing the root-worm. These two plats were sprayed July 11. The results showed that between 90 and 95 per ct. of all nymphs of the leaf-hoppers hit with the spray were killed. On July 14 another section of Mr. Sackett's vineyard was sprayed. "Atomic Sulphur and Arsenate of Lead," a proprietary mixture, was used at the rate of 4 lbs. to 100 gals. to kill the root-worm, and tobacco extract was used at the rate of 1 to 65 for the leaf-hopper. The second plat was sprayed with lime-sulphur solution, at the rate of 1 gal. to 100 gals. with tobacco extract at the rate of 1 gal. to 65 gals. of water. The results were similar to those on the first section. Having learned that the tobacco extract could be combined with other insecticides and that its killing properties were not impaired,

it was decided to try weaker solutions. Several plats were sprayed using tobacco extract, 1 gal. to 100 gals. of water, and several more plats using tobacco extract 1 gallon, lime-sulphur 1 gallon, and water 100 gallons. The results, so far as leaf-hopper is concerned, were very gratifying, but it was seen that the lime-sulphur burned the foliage rather badly. However, the plat sprayed with the lime-sulphur and tobacco extract showed the same injury to the grape clusters as when lime-sulphur was used alone. Owing to considerable trouble with lime-sulphur solutions on grape foliage this matter is treated under a separate heading (p. 579).

Lime-sulphur solution.— This preparation testing 32° Beaumé was used alone at the rate of 1 gal. to 100 gals. of water. It was also combined with the tobacco extract, using the lime-sulphur at the same strength as above and adding 1 gallon of the tobacco extract to 100 gallons. To our surprise the lime-sulphur alone killed as many hoppers as when used with tobacco extract. It was also as effective as the tobacco extract alone. Thus it seemed that we had found a cheap, practicable remedy for the leaf-hopper since lime-sulphur solution could be bought for 16 cents per gallon while the tobacco extract cost 85 cents per gallon. In this, however, we were doomed to disappointment since in about a week's time we found that the lime-sulphur solution, even as dilute as 1 gal. to 100 gals. of water, burned the foliage badly. The effect on the clusters which was noticed at picking time is explained on page 580.

SECORD VINEYARD.

In order to prove that the results in Mr. Sackett's vineyard were due to the sprays used and not to other factors, these experiments were repeated in Mr. Charles Secord's vineyard. The conditions of the spraying operations were similar except that the nymphs were more mature in the latter vineyard.

Black-Leaf Tobacco Extract.—This material was used in the following proportions and mixtures: Tobacco extract, 1 gal. to 65 gals. of water; 1 gal. tobacco extract, 4 lbs. arsenate of lead, water 100 gals.; tobacco extract 1 gal. with 100 gals. bordeaux mixture

(8-8-100); tobacco extract 1½ gals., lime-sulphur solution 1 gal., arsenate of lead 6 lbs., water 100 gals. Although the vines were large, the foliage dense and the nymphs larger than in the preceding experiments the results were the same. Black-Leaf Tobacco Extract at all the strengths used and with all the various mixtures killed most of the nymphs.

Lime-sulphur solution.— This again showed its killing power as an insecticide when used 1 gal. to 100 gals. of water, either alone or with tobacco extract. The burning of the foliage, however, was severe and the effect on the fruit was the same as in Mr. Sackett's vineyard.

Resin fish-oil soap.— This was used at the rate of 10 lbs. of soap to 100 gals. of bordeaux mixture (8-8-100) and failed to control the hoppers.

HORTON VINEYARD.

Of the three vineyards used in these tests, that of Mr. Charles Horton was the most severely infested with leaf-hopper. It comprised ten acres, divided equally between Concords and Niagaras, all of which were sprayed. The nymphs were nearly mature and in some places the foliage was dense where the leaf-hoppers were few, but the leaves were scanty and badly injured where the infestation was most severe. There were few root-worms in the vineyard. As Mr. Horton had already sprayed twice with bordeaux mixture and arsenate of lead the only materials used in the experiments were those intended to kill the hoppers.

Resin fish-oil soap.— This material was used at the rate of 10 lbs. to 100 gals. of water, but the results were very poor as only a few hoppers were killed.

Black-Leaf Tobacco Extract.—The following dilutions were used: 1 gal. extract to 90 gals. of water; 1 gal. of extract to 100 gals. of water. It was used with lime-sulphur solution as follows: tobacco extract 1 gal., lime-sulphur solution 1 gal., water 100 gals.

The results by all of the mixtures were good. The vines were cleaned of nymphs wherever the spray hit them. The number of nymphs killed was no greater when the lime-sulphur was added

than when the tobacco extract was used alone. The lime-sulphur solution always caused serious burning of the foliage.

Lime-sulphur solution.— This was used at the rate of one gallon of the solution to 100 gallons of water, both alone and with the tobacco extract. It killed as many nymphs when used alone as in combination with the tobacco extract but, as in the previous vineyards, the burning of the foliage was severe. It was noted that the vines most seriously infested with the leaf-hoppers had the most severe burning of the foliage by the lime-sulphur solution. This emphasizes the fact that lime-sulphur injury to foliage is influenced greatly by the condition of the foliage previous to the spraying.

SUMMARY OF THE RESULTS OF EXPERIMENTS.

Resin fish-oil soap.— This material did not control the leaf-hopper when used at the rate of 10 pounds to 100 gallons of water, either alone or when used in combination with the bordeaux mixture and arsenate of lead.

No chemical analysis of the soap was made and the results indicate that either the soap was not of the best quality or, if the soap was of standard strength, that it was used at too great a dilution for a geared sprayer. If the leaves are drenched with the soap at the above dilution the nymphs may be killed.

Black-Leaf Tobacco Extract.—This nicotine preparation was used at dilutions of 1 to 65, 1 to 90 and 1 to 100, both alone and with other insecticides and fungicides. In every case it proved an efficient spray for leaf-hoppers.

Lime-sulphur solution.— Of late years this material has been used as a summer spray on apples, pears and other fruits. For the past three years there have been numerous attempts by grape growers to use the lime-sulphur solution as a fungicide for grapes and accordingly it was tried to determine its effectiveness on the nymphs. Having learned by previous experience during 1910 that the lime-sulphur solution at or stronger than 1 gal. to 75 gals. of water would burn the foliage, it was not tried at any other dilution than 1 gal. to 100 gals. of water. At this strength when used

alone or in combination with other insecticides it killed the nymphs and, judging from the number of very small nymphs which later appeared in the plats sprayed by other mixtures, the lime-sulphur solution seemed also to destroy the eggs of the leaf-hopper. It cleaned up the leaves very thoroughly and, as far as destruction of the nymphs is concerned, is all that could be desired. However, the severe injury to foliage and fruit of both Niagara and Concord varities (see p. 510) forbids its use as a summer spray for grapes in the Chautauqua grape-belt; at least, until some method is discovered of applying the lime-sulphur solution without harmful effects on the leaves.

MANNER OF SPRAYING FOR GRAPE LEAF-HOPPER.

Since the method of fighting the leaf-hopper differs from those employed against other grape insects, a description is given of the spraying machine used in these experiments:

The machines are of the type used in most vineyards — horse-power sprayers. The pump is driven from the wheel by various mechanical devices as chain and sprocket wheels or eccentrics. The fixed nozzles were either taken off and the ends of the pipes closed by means of screw caps or a piece of leather was placed in each nozzle and the cap screwed into place. In the place of the lower nozzles two pieces of hose, each fifteen feet long, were attached. (Plate L, fig. 1.) These had extension rods of gas pipe which were four feet in length. To each rod was attached a cross pipe carrying two cyclone nozzles at right angles to the axis of the extension rod. (Plate L, fig 2.) This is a modification of the extension rod and nozzles used by Prof. Slingerland. With this extension rod one can apply the spray to the under sides of the leaves and thus get the material where the nymphs are located. (Plate L, fig. 3.) By driving slowly the two men handling the nozzles can direct the spray and reach all the leaves, and at the same time have sufficient pressure to do efficient work. The success of the operation will depend upon the work of the men at the nozzles. They must work fast and make an effort to hit the

under sides of all the leaves. With this outfit between five and six acres were sprayed in a day, using about 100 gallons of mixture per acre. Machines used for this work would be much more efficient if they had an auxiliary pump with a large air chamber, that could be used with the regular pump when spraying for this insect as short stops to thoroughly spray the vines would not so seriously affect the pressure.

Perhaps for this insect outfits using a gasoline engine, compressed air or compressed carbonic-acid gas, would do better work when the foliage is dense, since more time could be taken to spray each vine without such loss of pressure as is liable to occur with the geared sprayers.

RECOMMENDATIONS.

Resin fish-oil soap.— This material did not give very satisfactory results which may be due to two causes: the soap may have been of inferior quality or it may have been used at too great a dilution. If the material is to be applied by means of a geared sprayer, especially if it has but one pump, it should be applied at a greater strength than 10 pounds to 100 gallons of water. When the foliage can be drenched as by a machine which will keep up a high pressure at a very slow walk or when a hand-power pump is used the material no doubt will be effective when applied at the above strength.

Nicotine preparations.— Only one nicotine preparation was used in our experiments. This was the Black-Leaf Tobacco Extract. It is aimed to try other mixtures of a similar nature. This nicotine product was very efficient when used as dilute as one gallon to 100 gallons of water since it killed the leaf-hoppers and did not injure the foliage. We can therefore recommend it for trial against these insects.

There is at present no simple method of making a nicotine product from tobacco that will yield a uniform strength of nicotine because the tobacco varies in the amount of nicotine it contains. The determination of the amount of nicotine must be done by chemical analysis. If a nicotine preparation is bought, it should

be guaranteed to contain a certain amount of nicotine and should be diluted accordingly. Black-leaf Tobacco Extract has 2.7 per ct. nicotine in the concentrated product and when diluted one gallon to 65 gallons of water contains 1/20 of one per ct. of nicotine. This may serve as a guide for dilutions of other mixtures when the percentage of nicotine in the concentrate is known.

Lime-sulphur solution.— Lime-sulphur solution was found to kill the nymphs when used as dilute as one gallon to 100 gallons of water, but the severe injury to foliage forbids its use until a method of preventing injury is discovered. Any use of this material, at least for Chautauqua county, should be in an experimental way in a restricted area.

Manner of application.—Any material that is used to kill the leaf-hopper must be applied with a strong pressure to the lower sides of the leaves and at the time the insects are in the nymph form which is during the first part of the month of July.

LIME-SULPHUR INJURY TO GRAPES.

For several years commercial lime-sulphur solution has been advocated as a fungicide but very few experiments have been recorded in which it was used on grapes. In our work in Chautauqua county it was tried as a repellent for the grape-blossom midge at dilutions ranging from 1-40 to 1-60 and every vine sprayed with the solution suffered severe injury to the foliage. These were Moore Early grapes and as there was much rain before and after the vines were sprayed the burning was believed at first to be augmented by weather conditions but later experiments showed that lime-sulphur solution would no doubt have caused damage even if the weather had been favorable.

The lime-sulphur solution was used with arsenate of lead on Concord and Niagara grapes as a combined insecticide and fungicide for both the rose-chafer and the adult Fidia. It was tried at dilutions of 1-50 and 1-75 and both mixtures caused severe injury.

In spraying for the control of the grape leaf-hopper the lime-sulphur solution was used at the dilution of 1-100 both alone and with the Black-Leaf Tobacco Extract. Even so dilute a solution burned the foliage severely. Here, however, the amount of burning varied with the amount of leaf-hopper injury but leaves having few insect punctures were rather badly burned.

There were nearly eight acres of grapes sprayed with the lime-sulphur solution during 1910 and the material was used at dilutions varying from 1-40 to 1-100, applied during a period of over two months and under varying weather conditions.

While the lime-sulphur spraying caused considerable damage to the foliage, more serious injuries occurred to the fruit clusters which were not noticed until the harvesting of the fruit. Most Concord vines that had been sprayed with the lime-sulphur solution were found to have clusters on which were many green grapes (Plate LI). The following points of interest were found from a study of these conditions:

1. The berries had seeds and, therefore, the condition does not appear to have been caused by imperfect fertilization of the grape flowers.

2. In some manner not understood the lime-sulphur solution stopped the growth shortly after the spraying and the berries, even though remaining on the stems, never ripened. It will be noted that the green berries on the various clusters are of different sizes. This represents the sizes of the berries at the time the grapes were sprayed. For example: The lower bunches in Plate LI are from a vine sprayed for root-worm on July 6, but the upper cluster shown is from a vine sprayed for leaf-hoppers on July 15. These are representative clusters.

3. The amount of injury was directly proportional to the amount of spray that lodged on the berries. Vines with scanty foliage showed a greater loss than vines having heavy foliage. This refers to vines in vineyards which were sprayed for the root-worm where most of the spray is directed upon the upper surfaces of the leaves. The greatest loss was in the vineyards that were

sprayed for the leaf-hopper where the spray was thrown against the lower surfaces of the leaves and thus more of the clusters were covered with the spray.

The reduction in the yield of fruit is considerable but the greatest loss is caused by the expenditure of time and labor to remove these green berries before packing. This injury by the lime-sulphur solution is regrettable from an entomological point of view since the leaf-hopper can easily be killed by using the lime-sulphur solution as dilute as 1-100, which makes it possible to spray an acre for about twenty cents for the material. It is recommended that grape growers do not use this material on their vines except in an experimental way until there is more knowledge of the conditions under which this spray can safely be used.

REPORT

ON WORK WITH

Field Crops.

W. H. JORDAN, *Director.*
F. A. SIRRINE, *Special Agent.*

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REPORT ON FIELD CROPS.

POTATO FERTILIZERS: METHOD OF APPLICATION AND FORM OF NITROGEN.*

W. H. JORDAN AND F. A. SIRRINE.

SUMMARY.

Tests were made in three localities on Long Island during four successive years, to compare broadcast application of commercial fertilizers on potato fields with applications in the row, and to compare organic nitrogen (from dried blood) with inorganic nitrogen (from nitrate of soda) in potato fertilizers. Incidentally, comparison was made between different quantities of fertilizer — 500 lbs. to the acre, 1000 lbs. and 1500 lbs.

Drought interfered seriously with the tests, and the differences shown in either of the principal lines of comparison were small. There was apparently a slight advantage for row application of fertilizer rather than broadcast application. So far as actual figures indicate, the source of nitrogen was immaterial; but field observations showed more rapid growth of vines from the nitrate of soda whenever there was sufficient rainfall. All amounts of fertilizer used gave compensating increases in yield; but, on the whole, no amount was very profitable, 1500 lbs. making the poorest showing.

* A reprint of Bulletin No. 327.

INTRODUCTION.

Potato-growing is a subject of special interest and importance in New York. This State leads in both acreage grown and total production of these tubers; but since it is far from the front in average acre yields, it is evident that there are many points in the culture of the crop that are either not known by growers in the State or, if known, are not practiced by them. In the use of fertilizers, for example, there is great diversity of opinion and practice; and this is particularly true on Long Island, where fertilizers are applied, on all garden and field crops, more generally and more lavishly than perhaps anywhere else in the State. The work of this Station in previous years[1] has proven quite conclusively that large quantities of commercial fertilizer have been used without profit in growing potatoes on the Island; since tests on several farms, continued through a series of years, showed, almost without exception, that to use more than 1,000 pounds of high-grade commercial fertilizer to the acre is not so profitable as to use that amount or less. Other tests showed the fallacy of prevalent beliefs in the necessity of large amounts of potash, preferably the sulphate, in potato fertilizers for use on Long Island; since fertilizer formulas containing little or no potash gave as good results as those containing 8 or 10 per ct.; and muriate gave as good results as sulphate.

It appears that the teachings of the Station have not been so generally heeded as would be profitable; since reports are common of potato fields where a ton or more of fertilizer is still used to the acre, and the brands of "potato" fertilizers popular on the Island still call for 5 to 8 per ct. of potash.

These facts in fertilizer application are, or should be, known; but they are not commonly utilized. While their general adoption would not increase the average yields, it would prevent considerable direct financial loss in the effort to secure such an increase.

Many other features of fertilizer application on Long Island are still vigorously discussed; and in an effort to clarify the situa-

[1] Bulletins 93, 112, 137, 154 and 187.

tion with regard to a few practices the Station has carried on tests in three places for four successive years, 1905 to 1908 inclusive.

OUTLINE OF EXPERIMENTS.

OBJECTS.

These experiments were in two series: In Series I the object was to determine whether it is better to apply all the fertilizer in the soil near the seed potato, that is, in the open drill mark or furrow in which the seed is planted, or to distribute it as uniformly as possible through the whole upper portion of the soil of the field. In Series II the nitrogen in the fertilizer came in one case wholly or in large part from inorganic materials, in the other case wholly or in large part from organic materials.

In both series is was possible to secure data regarding different amounts of fertilizer used; as in Series I successive areas of the plats, whether fertilized in the drill or broadcast, received no fertilizer, 500 lbs. to the acre, 1000 lbs. or 1500 lbs.; while in Series II check plats were left unfertilized to give a comparison with the fertilized rows which received 1000 lbs. of fertilizer to the acre.

PLAN, LOCATION AND GENERAL CONDITIONS.

The arrangement of the plats on each of the farms may be quickly fixed in mind by study of the diagram on the next page. This also conveys quite a good idea of the plan of the separate tests, which will, however, be discussed in detail later. The arrangement of plats indicated was followed with little change; but once or twice slight variations of order were necessary to bring each series with its checks on land of uniform character and treatment. These changes, with one exception, in no way affected the comparisons. Each plat contained one-tenth of an acre and was separated from its neighbors by the width of a row. Four rows were planted on each plat and while the width devoted to a row varied from 33 to 36 inches the length of the plat was also varied to give the required area.

Farms used.— The experiments were continued for four years. At Cutchogue they were for three years on the farm of W. A.

PLATS, 1/10 ACRE EACH.

1 No fertilizer
2 50 lbs. fertilizer — broadcast
3 50 lbs. fertilizer — in drill
4 100 lbs. fertilizer — broadcast
5 100 lbs. fertilizer — in drill.
6 150 lbs. fertilizer — broadcast
7 150 lbs. fertilizer — in drill.
8 No fertilizer
9 As on 2
10 As on 3
11 As on 4
12 As on 5
13 As on 6
14 As on 7
15 No fertilizer
16 100 lbs. fertilizer: N, ⅓ inorganic, ⅔ organic
17 100 lbs. fertilizer: N, ⅔ inorganic, ⅓ organic
18 As on 16
19 As on 17
20 No fertilizer
21 100 lbs. fertilizer: N, all organic
22 100 lbs. fertilizer: N, all inorganic
23 As on 21
24 As on 22

DIAGRAM 1.— PLAN OF LONG ISLAND POTATO FERTILIZER EXPERIMENTS.

Fleet and one year on that of W. M. Fogarty; at Riverhead on the farms of F. W. Downs, C. W. Downs and F. A. Sirrine (last two years); at Baiting Hollow on the farm of D. L. Downs for two years, omitted the third year, and for the fourth year on the farm of I. W. Young, near Centerville. All these farms are of the same general type — sandy loam to good sandy loam, underlaid by sand and gravel, which occasionally approaches the surface. All are practically level or without irregularities which would cause marked variations in yield on compared plats. Where any such disturbing factors were evident, the plats were shifted or rearranged so as to overcome or neutralize as far as possible any influence these factors might have on yields.

Thus, on the field at Baiting Hollow, used the second year, several small depressions ("kettle holes") came in the test area; and the plats were so arranged that duplicate plats should not both contain a "kettle hole."

Previous history of fields.— The previous history of the fields on which the plats were located was learned as far as possible, especially with reference to recent cropping and fertilization, and areas showing marked variations were rejected. In spite of this care, however, it was found that one field (Baiting Hollow, 1905) had been so enriched for previous crops that the fertilizers used in the test were practically without effect. In another instance also (Riverhead, 1906) certain plats showed by appearance of the soil under cultivation and by the growth of vines that the soil on these plats was originally lighter than that on other plats or that the other plats had at some previous time been manured. In other cases the turning down of sod in the spring, with subsequent lack of sufficient moisture to promote decay and re-establish capillarity, made the results unreliable, especially with regard to the effect of different quantities of fertilizer. This was the condition on part of the Cutchogue field in 1907 and on part of the Riverhead field in 1908. For these reasons it has been thought advisable, in computing the tables of averages, to exclude some plats or fields.

Crop management.— In preparation of the soil and general methods of planting and caring for the crops the growers followed

their usual customs, the Station requirement being that all compared plats should have uniform treatment throughout and all be sprayed with bordeaux mixture and paris green. No two fields, therefore, were plowed, harrowed or cultivated alike, planted in the same way or with the same seed, or given quite the same treatment for insects and diseases; so that comparisons, field with field, are not justifiable; but comparisons should hold between plats in the same fields, modified by general climatic conditions, as noted later, and by special conditions which occasionally demanded rejection of results, as discussed in the previous section.

Other factors affecting results.— During the period through which these tests were continued severe droughts have interfered seriously with crop growth and undoubtedly modified and in some instances probably reversed the normal effect of some of the factors under consideration. In only one of the four years, 1906, was the rainfall during July and August sufficient to mature potatoes properly. Under these conditions it is exceedingly doubtful whether the soil had enough moisture at times to give effective solutions of the fertilizers present, so that the lack of striking results in the summarized data may be largely due to weather conditions rather than to uniformity of effect of different quantities of fertilizers, different methods of application or different forms of nitrogen. The entire course of the tests brings out strongly the practical impossibility of securing accurate scientific data from field tests. Such tests can be used only as *indications* of the needs of the soil. Insects and diseases affecting the foliage of the potatoes were usually well controlled. Colorado beetles, flea beetles and late blight injured some of the fields to quite an extent, but the damage was so distributed that it probably did not affect any of the comparisons. Scab was prevalent in some of the old fields, though controlled as far as possible by seed treatment, and its effects are probably reflected in some of the results, since scabby potatoes weigh from 5 per ct. to 25 per ct. less than sound tubers. Rhizoctonia stem rot was also a factor in determining yields, many of the fields being considerably affected by this disease. It is practically impossible to estimate the effect of these minor factors or to

allow for them, but their influence extends so generally through all the plats in a field that their aggregate effect is probably neutral so far as the present comparisons are concerned.

TEST OF METHOD OF APPLICATION OF FERTILIZER.

FERTILIZER USED.

Composition.— The fertilizer used in this test was home-mixed, from high-grade materials, to give about 4 per ct. of nitrogen, 7¾ per ct. of phosphoric acid and 5 per ct. of potash. The materials used were acid phosphate, muriate of potash, dried blood and nitrate of soda, the latter two being so proportioned that 5 parts of the nitrogen came from blood (organic) and 2 parts from the nitrate (inorganic). The composition was based upon the manufacturers' guarantees, not on Station analysis.

Mixing.— The materials were carefully fined and mixed by hand on a smooth floor, a larger quantity being mixed than was required for the particular lot being weighed up and one pound more than the specified amount placed in each bag to allow for adhesion to the bag, accidental scattering and similar slight losses. As an illustration of the method of mixing: When 6 100-lb. lots were needed the following quantities were mixed:

Acid phosphate, 14 per ct.	360 lbs. +	30 lbs. =	390 lbs.
Muriate of potash, 50 per ct.	60 lbs. +	5 lbs. =	65 lbs.
Nitrate of soda, 15 per ct.	120 lbs. +	10 lbs. =	130 lbs.
Dried blood, 10 per ct.	60 lbs. +	5 lbs. =	65 lbs.
	600 lbs. +	50 lbs. =	650 lbs.

From this quantity, after thorough mixing, 6 bags were put up each containing 101 lbs. and the remaining amount added to the next lot mixed. All additions to the quantities called for by formula were made in the same ratio, one-twelfth, so that the same percentages were maintained.

METHODS OF APPLYING.

The fertilizer was usually applied after the rows had been marked out but before the drills or furrows were opened. On the

broadcast plats it was spread as uniformly as possible over the whole surface of the plat, being worked into the soil by the subsequent harrowings and cultivations. On the plats where the fertilizer was applied in the drills or rows it was usually spread by hand as close to the marker furrow as possible and a deeper furrow for planting then opened, which process distributed the fertilizer considerably. Occasionally where a planter was used the furrows were first opened by the planter with coverers removed, the fertilizer distributed by hand in the open furrow, and the seed then dropped and covered by the machine.

As indicated by the diagram broadcast and drilled plats alternated; and the successive pairs of plats received increasing amounts of fertilizer at the rates of 500 lbs., 1000 lbs. and 1500 lbs. to the acre.

Plats 1 and 8 were check plats and plats 9-14, in pairs, duplicated the pairs in plats 2 to 7.

RESULTS.

The data for these plats are shown in Table I, the yields being

TABLE I.—YIELD OF POTATOES WITH DIFFERENT AMOUNTS OF FERTILIZER, BROADCAST AND DRILLED
1905

Amount of fertilizer to the acre	Plat No.	Method of application	Potatoes on tenth-acre plats in series at—					
			Cutchogue		Riverhead		Baiting Hollow	
			Large	Total	Large	Total	Large	Total
Lbs.			*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
None....	1	....	763	828	738	836	1,684	1,733
500	2	Broadcast......	875	950	995	1,031	1,863	1,899
500	3	Drilled.........	719	789	945	1,020	1,920	1,948
1,000	4	Broadcast......	971	1,036	1,156½	1,222½	1,809	1,845
1,000	5	Drilled.........	1,029	1,094	1,230	1,293	1,786	1,810
1,500	6	Broadcast......	850	913	1,311	1,371	1,673	1,695
1,500	7	Drilled.........	925	992	1,469	1,543	1,665	1,717
None	8	....	808	878	891	993	1,846	1,908
500	9	Broadcast......	916	976	1,115	1,189	1,781	1,859
500	10	Drilled.........	972	1,017	1,175	1,261	1,643	1,731
1,000	11	Broadcast......	1,165	1,215	1,188	1,268	1,674	1,743
1,000	12	Drilled.........	1,217	1,262	1,303	1,377	1,718	1,802
1,500	13	Broadcast......	1,223	1,263	1,362	1,432	1,677	1,780
1,500	14	Drilled.........	1,049	1,094	1,581	1,652	1,585	1,661½

TABLE I (*Continued*)—YIELD OF POTATOES WITH DIFFERENT AMOUNTS OF FERTILIZER, BROADCAST AND DRILLED.

Amount of fertilizer to the acre.	Plat No.	Method of aplpication	Potatoes on tenth-acre plats in series at—					
			Cutchogue		Riverhead		Baiting Hollow	
			Large	Total	Large	Total	Large	Total
			1906					
Lbs.			*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
None	1	....	1,218	1,273	588	638	285½	434½
500	2	Broadcast......	1,181	1,253	745	782	328½	464½
500	3	Drilled.........	1,195	1,264	824	874	361	487
1,000	4	Broadcast......	1,084	1,159	789	837½	380	504
1,000	5	Drilled.........	1,221	1,281	869	907	408	524
1,500	6	Broadcast......	1,402	1,455	1,041	1,099½	365	486
1,500	7	Drilled.........	1,398	1,455	1,023	1,078	405	512
None	8	....	*1,081	*1,158	710	771	142	243
500	9	Broadcast......	1,346	1,408	816	875	212	340
500	10	Drilled.........	1,439	1,498	749	794	236	364
1,000	11	Broadcast......	1,447	1,504	698	748	192	291
1,000	12	Drilled.........	1,423	1,484	808	859	243	355
1,500	13	Broadcast......	1,507	1,567	751	794	390	561
1,500	14	Drilled.........	1,510	1,568	706	770	503	669
			1907					
None	1	....	721	826	842	966½	.....	......
500	2	Broadcast......	877	982	814	933	.....	......
500	3	Drilled.........	1,003	1,105	880	1,007½	.....	......
1,000	4	Broadcast......	1,035	1,155	918	1,040	.....	......
1,000	5	Drilled.........	973	1,093	918	1,053	.....	......
1,500	6	Broadcast......	942	1,006	921	1,031	.....	......
1,500	7	Drilled.........	928	999	969½	1,067	.....	......
None	8	....	866	934	*1,013½	*1,122	.....	......
500	9	Broadcast......	1,165	1,258	885½	995	.....	......
500	10	Drilled.........	976	1,046	949	1,074	.....	......
1,000	11	Broadcast......	1,028	1,133	951	1,081½	.....	......
1,000	12	Drilled.........	1,064	1,164	1,023	1,162	.....	......
1,500	13	Broadcast......	910	1,012	1,015	1,130½	.....	......
1,500	14	Drilled.........	794	934	1,105	1,206	.....	......
			1908					
None	1	....	291½	362½	938½	1,164½	637	772
500	2	Broadcast......	345	429½	931½	1,171½	†	†
500	3	Drilled.........	487	565	925	1,147	707	844
1,000	4	Broadcast......	468	544	950	1,152	692	836
1,000	5	Drilled.........	601½	685½	968½	1,167	686	812
1,500	6	Broadcast......	549	636	953	1,159	765	907
1,500	7	Drilled.........	574	650½	954	1,162½	733	853
None	8	....	339	415	1,009½	1,190	661	782
500	9	Broadcast......	429½	548½	984½	1,164	†	†
500	10	Drilled.........	442	499	1,034½	1,249½	591	715
1,000	11	Broadcast......	429	547	967½	1,162	594	712
1,000	12	Drilled.........	578	695	897	1,098	606	731½
1,500	13	Broadcast......	493	584	842½	1,027½	632	765
1,500	14	Drilled.........	595	667	886	1,099	664	801

* Plat 14 really used as check in Cutchogue series in 1906 and in Riverhead series in 1907; plats numbered 9-14 were really 8-13. † Plats omitted because of lack of room.

shown in pounds of large (marketable) tubers and in pounds of total yield. The table is divided into sections by years. In Table II the acre-yields have been calculated from the averages of the plats, the first three sections showing the averages for the tests in the three different localities and the last section the averages for the three localities. The final two columns of this last section summarize the entire situation, and show, on the basis of all the figures, that there was, under the climatic conditions prevailing during these four years, surprisingly little difference in effect between concentrating the fertilizer near the plants and spreading it through the soil. The plats with fertilizer in the potato rows averaged only 2.3 bu. more of marketable potatoes to the acre or 3 bu. more of total yield.

TABLE II.—INFLUENCE OF METHOD OF APPLYING FERTILIZER ON YIELD OF POTATOES

CUTCHOGUE

Treatment: 500, 1,000 or 1,500 pounds of fertilizer to the acre	Acre yields calculated from averages of plats in—									
	1905		1906		1907		1908		All years	
	Large	Total	Large	Total	Large	Total	Large	Total	Large	Total
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Drilled........	164.2	173.5	227.3	237.5	159.3	176.2	91.0	104.5	160.5	173.2
Broadcast.....	166.7	176.5	221.3	231.8	165.5	181.8	75.4	91.3	157.2	170.4
Difference.....	−2.5	−3.0	6.0	5.7	−6.2	−5.6	15.6	13.2	3.3	2.8
RIVERHEAD										
Drilled........	214.0	226.3	138.3	146.7	162.3	182.5	157.3	192.7	168.0	187.0
Broadcast.....	198.0	208.7	134.5	142.7	153.0	172.5	156.3	189.8	160.5	178.4
Difference.....	16.0	17.6	3.8	4.0	9.3	10.0	1.0	2.9	7.5	8.6
BAITING HOLLOW										
Drilled........	286.5	296.3	59.8	80.8	......	......	110.8	132.1	†152.4	†170.0
Broadcast.....	291.0	300.5	51.9	73.5	......	......	*111.8	*134.3	†151.8	†168.8
Difference.....	−4.5	−4.2	7.9	7.3	......	......	−1.0	−2.2	0.6	1.2
AVERAGES FOR THREE LOCALITIES										
Drilled........	221.6	232.0	141.8	155.0	‡160.8	‡179.3	119.7	143.1	160.3	176.7
Broadcast.....	218.6	228.6	135.9	149.3	‡159.3	‡177.1	114.5	138.5	158.0	173.7
Difference.....	3.0	3.4	5.7	5.7	1.5	2.2	5.2	4.6	2.3	3.0

* Broadcast plats with 500 lbs. fertilizer omitted. † Average for three years only.

Table III gives, perhaps, a fairer idea of the difference in effect between the two methods of application; for in this table those fields have been omitted, which from mere inspection, appeared unfitted to give dependable results. These are the field at Baiting Hollow in 1905, with a large residue of unused manure and fertilizer from the previous year, and those at Cutchogue in 1907 and Riverhead in 1908, on sod turned under in the spring. In this table the gains are small, but consistent, in favor of application in the drill, with an average increase in large potatoes for the three localities and eight comparisons, of 7.3 bu. per acre.

TABLE III.—SUMMARY OF INFLUENCE OF METHOD OF APPLYING FERTILIZER ON YIELD OF LARGE POTATOES

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

Method of application	1905	1906	1907	1908	All years
Drilled	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Broadcast	189.1	141.8	162.3	100.9	148.5
Difference in favor of drilling	182.3	135.9	153.0	93.6	141.2
	6.8	5.7	9.3	7.3	7.3

TESTS OF FORMS OF NITROGEN.

PLAN.

This test was in two parts: Part I, in which the two forms of nitrogen, organic in dried blood and inorganic in nitrate of soda, were used in combination, one-third of the nitrogen in one form with two-thirds in the other form, the proportions being reversed on the alternate plats. This line of tests was carried through the full four years. In Part II, inaugurated the second year of the experiments, all the nitrogen on one plat was from dried blood and all on the other from nitrate of soda. Duplicate plats for each application and a check plat were provided in each locality.

The nitrogen, whatever the form, was home-mixed with acid phosphate and muriate of potash to make a complete fertilizer. This had the composition, approximately, of 4 per ct. of nitrogen, $7\frac{3}{4}$ per ct. of phosphoric acid and $4\frac{3}{4}$ per ct. of potash when the forms of nitrogen were combined (Part I); and of 4 per ct. of nitrogen, 8 per ct. of phosphoric acid and 5 per ct. of potash when each form of nitrogen was used alone (Part II).

The fertilizer in these nitrogen tests was all applied in the drill.

TABLE IV.—YIELD OF POTATOES WITH ORGANIC AND INORGANIC NITROGEN IN FERTILIZERS

PART I. TWO FORMS IN COMBINATION

Plat No.	Fertilizer: 1,000 lbs. to the acre 4%N—$7\frac{1}{4}$%P_2O_5—$4\frac{3}{8}$%K_2O		Potatoes on tenth-acre plats in series at —					
			Cutchogue		Riverhead		Baiting Hollow	
			Large	Total	Large	Total	Large	Total
			Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
	1905							
1	No fertilizer..............		1,098	1,148	835	933	1,642	1,759
	Nitrogen:							
	Organic	Inorganic						
2	Two-thirds	One-third	1,254	1,299	1,127	1,209	1,482	1,581
3	One-third	Two-thirds	1,361	1,401	1,347	1,424	1,612	1,740
4	Two-thirds	One-third	1,351	1,391	1,343	1,420	1,580	1,649½
5	One-third	Two-thirds	1,363	1,423	1,286	1,376	1,648	1,721
	1906							
1	No fertilizer..............		1,081	1,158	*644	*690½	*212½	*330¾
	Nitrogen:							
	Organic	Inorganic						
2	Two-thirds	One-third	1,375	1,438	1,091	1,139	267½	371½
3	One-third	Two-thirds	1,362	1,427	1,225	1,280	437	574
4	Two-thirds	One-third	1,309	1,369	766	831	382½	554½
5	One-third	Two-thirds	1,336	1,396	875	940	574½	710½
	1907							
1	No fertilizer..............		*928½	*1,065	*1,068¾	*1,185½	†	†
	Nitrogen:							
	Organic	Inorganic						
2	Two-thirds	One-third	981	1,114	1,139	1,250		
3	One-third	Two-thirds	992	1,125	1,129	1,229		
4	Two-thirds	One-third	866	976	1,108	1,212½		
5	One-third	Two-thirds	1,004	1,144	1,080½	1,186½		
	1908							
1	No fertilizer..............		*415	*481	*820¾	*1,033½	645¾	786
	Nitrogen:							
	Organic	Inorganic						
2	Two-thirds	One-third	555	614	1,009	1,185½	686½	846½
3	One-third	Two-thirds	550	613½	926½	1,111½	655	810
4	Two-thirds	One-third	536	580	926	1,111	670	823
5	One-third	Two-thirds	561	617	775	953	681	858

* Average of two plats. † Area reserved for test at Baiting Hollow found unsuited to purpose.

TABLE IV (*Continued*).—YIELD OF POTATOES WITH ORGANIC AND INORGANIC NITROGEN IN FERTILIZERS

PART II. EACH FORM SEPARATE

1906

Plat No.	Fertilizer: 1,000 lbs. to the acre 4%N—8%P_2O_5—5%K_2O	Potatoes on tenth-acre plats in series at —					
		Cutchogue		Riverhead		Baiting Hollow	
		Large	Total	Large	Total	Large	Total
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	No fertilizer	1,081	1,158	*644	*690½	212½	330¾
	Nitrogen:						
2	All organic	1,401	1,461	1,060	1,103	274	431
3	All inorganic	1,277	1,340	981	1,027	419	570
4	All organic	1,395	1,480	921	967	316	461
5	All inorganic	1,373	1,453	758	791	259	380

1907

1	No fertilizer	956	1,096	1,124	1,249		
	Nitrogen:						
2	All organic	1,134	1,239	1,138½	1,258½		
3	All inorganic	1,117	1,212	1,187½	1,312½		
4	All organic	969	1,099	983	1,103		
5	All inorganic	989	1,119	1,217	1,337		

1908

1	No fertilizer	415	473	774	970½	628	769
	Nitrogen:						
2	All organic	535	606½	851	1,020½	653	778
3	All inorganic	562	662	824	986½	695	866
4	All organic	576½	657½	778	920½	728	870
5	All inorganic	452	577	723½	919½	672	853

* Average of two plats.

RESULTS.

Table IV gives the detailed yields of the plats, the table being made up of two sections to correspond with the two parts of the tests. In Table V the acre-yields are computed from averages of the plats; and in Table VI, a general summary is given, excluding the plats on which the data were obviously valueless or misleading.

TABLE V.— INFLUENCE OF ORGANIC AND INORGANIC NITROGEN IN FERTILIZER ON YIELD OF POTATOES

A. TWO FORMS IN COMBINATION

CUTCHOGUE SERIES

Fertilizer: 1,000 pounds to the acre; 4% N—7¾% P_2O_5—4⅔% K_2O	Acre-yields calculated from averages of plats in									
	1905		1906		1907		1908		All years	
	Large	Total	Large	Total	Large	Total	Large	Total	Large	Total
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Check	183.0	191.3	180.2	193.0	154.8	177.5	69.2	80.2	146.8	160.5
N, ⅔ organic, ⅓ inorganic	217.1	224.2	223.7	233.9	153.9	174.2	90.9	99.5	171.4	183.0
N, ⅓ organic, ⅔ inorganic	227.0	235.3	224.8	235.3	166.3	189.1	92.6	102.5	177.1	190.6
*Difference	9.9	11.1	1.1	1.4	12.4	14.9	1.7	3.0	5.7	7.6

RIVERHEAD SERIES

Check	139.2	155.5	103.7	115.1	178.1	197.6	136.8	172.3	140.3	160.1
N, ⅔ organic, ⅓ inorganic	205.8	219.1	154.8	164.2	187.3	205.2	161.3	191.4	177.3	195.0
N, ⅓ organic, ⅔ inorganic	219.4	233.3	175.0	185.0	184.1	201.3	141.8	172.0	180.1	197.9
*Difference	13.6	14.2	20.2	20.8	—3.2	—3.9	—19.5	—19.4	2.8	2.9

BAITING HOLLOW SERIES

Check	273.7	293.2	35.4	55.1	......	......	107.7	131.0	†138.9	†159.8
N, ⅔ organic, ⅓ inorganic	255.2	269.3	54.2	77.2	......	......	113.0	139.1	†140.8	†161.9
N, ⅓ organic, ⅔ inorganic	271.7	288.4	84.3	107.0	......	......	111.3	139.0	†155.8	†178.1
*Difference	16.5	19.1	30.1	29.8	......	......	—1.7	—0.1	15.0	16.2

AVERAGES OF THREE SERIES

Check	198.6	213.3	107.6	121.1	‡166.5	‡187.6	104.6	127.8	144.3	160.1
N, ⅔ organic, ⅓ inorganic	226.0	237.5	144.2	158.4	‡170.6	‡189.2	121.7	143.3	162.3	180.0
N, ⅓ organic, ⅔ inorganic	239.4	252.3	161.4	175.8	‡175.2	‡195.2	115.2	137.8	171.0	188.9
*Difference	13.4	14.8	17.2	17.4	4.6	6.0	—6.5	—5.5	7.8	8.9

* " Difference " indicates advantage or disadvantage (—) for larger proportion of inorganic nitrogen.

† Average for three years only. ‡ Average for two series only.

TABLE V.—INFLUENCE OF ORGANIC AND INORGANIC NITROGEN IN FERTILIZER ON YIELD OF POTATOES (*Continued*)

B. EACH FORM ALONE

CUTCHOGUE SERIES

Fertilizer: 1,000 pounds to the acre; 4% N—8% P_2O_5—5% K_2O	Acre-yields calculated from averages of plats in							
	1906		1907		1908		All years	
	Large	Total	Large	Total	Large	Total	Large	Total
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Check	180.2	193.0	159.3	182.7	69.2	78.8	136.2	151.5
N, all organic	233.0	245.1	175.3	194.8	92.8	105.3	167.0	181.7
N, all inorganic	220.8	232.8	175.5	194.3	84.7	103.3	160.3	176.8
*Difference	—12.2	—12.3	0.2	—0.5	—8.1	—2.0	—6.7	—4.9

RIVERHEAD SERIES

Check	107.3	115.1	187.3	204.1	129.0	161.8	141.2	160.3
N, all organic	165.1	172.5	176.8	196.8	135.8	161.8	159.2	177.0
N, all inorganic	144.9	151.5	200.3	220.8	129.0	155.8	158.1	177.0
*Difference	—20.2	—21.0	23.5	24.0	—6.8	—3.0	—1.1	0.0

BAITING HOLLOW SERIES

Check	35.4	55.1	......	......	104.7	128.2	70.1	91.7
N, all organic	49.2	74.3	......	......	115.1	137.5	82.2	105.9
N, all inorganic	56.5	79.2	......	......	113.9	142.8	85.2	110.0
*Difference	7.3	4.9	......	......	—1.2	5.3	3.0	5.1

AVERAGES FOR THREE SERIES

Check	107.6	121.1	173.3	193.4	101.0	122.9	115.8	134.5
N, all organic	149.1	163.9	176.1	195.8	114.6	134.9	136.1	154.9
N, all inorganic	140.7	154.5	187.9	207.6	109.2	135.0	134.5	154.9
*Difference	—8.4	—9.4	11.8	11.8	—5.4	0.1	—1.6	0.0

* "Difference" indicates advantage or disadvantage (—) of inorganic nitrogen over organic nitrogen.

TABLE VI.— SUMMARY OF INFLUENCE ON YIELD OF POTATOES OF ORGANIC AND INORGANIC NITROGEN IN FERTILIZER

A. TWO FORMS IN COMBINATION

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

Fertilizer: 1000 pounds to the acre.	Acre-yields of large potatoes calculated from averages				
	1905	1906	1907	1908	All years
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*
N, ⅓ organic, ⅔ inorganic	223.2	161.4	184.1	102.0	167.9
N, ⅔ organic, ⅓ inorganic	211.4	144.2	187.3	102.0	161.2
*Difference	11.8	17.2	—3.2	0.0	6.7

*Advantage or disadvantage (—) for larger proportion inorganic nitrogen.

B. EACH FORM ALONE

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

N, all inorganic	......	140.7	200.3	99.3	146.8
N, all organic	......	149.1	176.8	103.9	143.3
*Difference	......	—8.4	23.1	—4.6	3.5

*Advantage or disadvantage (—) for inorganic nitrogen.

With these exclusions, the differences of effect between the forms of nitrogen are in opposite directions in equal numbers of cases and, on the whole, so small as to lie wholly within the limits of experimental error. The only conclusion that can be drawn from such data is that, under the climatic conditions prevailing during the time of these tests, there is no dependable difference between forms of nitrogen for potatoes on Long Island. It was observed on the Riverhead plats in 1908 that, on the plats receiving a large proportion of the nitrogen or all of it in nitrate of soda, as well as on plats in the previous test receiving the largest amount of fertilizer, the vines were larger and wilted quicker in the drought than those fertilized with more of the blood. The vines on these nitrate plats died earlier and the yield was less than on the compared plats. This indicates that under certain conditions a quick-acting source of nitrogen may be undesirable. Where moisture was plentiful at the right time, however, the quick-acting nitrate would be of advantage in promoting rapid early growth.

INFLUENCE OF QUANTITY OF FERTILIZER.

The data in Table I can also be so arranged as to show the comparative effect of no fertilizer and of amounts, increasing by 500 lbs., up to 1,500 lbs. to the acre; and the data in Table IV to show the effect of an application of 1000 lbs. to the acre. These rearrangements of the data, averaged by plats and computed to acre-yields, are shown in Tables VII and VIII; and the summaries, corrected by the omission of unreliable data, in Table IX. The "Gain" in Table VII and the first section of Table IX is for each increase of 500 lbs.; not, in case of the 1000 lbs. and 1500 lbs. plats, for the increase of these plats over the check plats. This method of showing results should be fair; but the change in position of the second check plat at Riverhead in 1907, as explained in a footnote to Table VIII, gives a decrease instead of an increase for 500 lbs. of fertilizer in that test.

Taking the summary for all years, as shown in the last column of Part I, Table IX, it appears that there was a slight, but consistent increase in yield with the increased amount of fertilizer applied. This increase probably just about paid for the fertilizer used, with little allowance for mixing or applying. A ton of fertilizer as good as used in these tests, would cost on the average, during the years of the tests, about $28, or $7 for each quarter-ton; and a fair average price for potatoes during the same time would be 65 cents a bushel; therefore, to pay for itself each 500-lb. application must produce an increase of 11 bu. of marketable potatoes. Each appears to have done this, with the margin very slight in the case of 1500 lbs. The same conclusion must be drawn if we consider the "form of nitrogen" tests in parts II and III of the table; for they show an average increase from the use of 1000 lbs. of fertilizer per acre of 24.1 bu. to the acre; and when these figures are united with those showing the gain from the 1000-lb. plats in Part I of the table, we have a gain of 24.6 bu. per acre. A much better showing is made if we consider the crops of 1905, only, which was the only one in which satisfactorily large yields were

TABLE VII.— INFLUENCE OF QUANTITY OF FERTILIZER ON YIELD OF POTATOES

Amount of fertilizer to the acre	Acre-yields calculated from averages of plats in —									
	1905		1906		1907		1908		All years	
	Large	Total	Large	Total	Large	Total	Large	Total	Large	Total
CUTCHOGUE SERIES										
Lbs.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
None.....	130.9	142.2	191.6	202.4	132.3	146.7	52.5	64.8	126.8	139.0
500.......	145.1	155.5	215.0	226.0	167.5	183.0	71.0	85.0	148.7	162.4
Gain......	14.2	13.3	24.4	23.6	35.2	36.3	18.5	20.2	21.9	23.4
1,000.....	182.6	192.0	215.7	226.2	170.8	189.4	86.5	103.0	163.9	177.7
Gain......	37.5	36.5	0.7	0.2	3.3	6.4	15.5	18.0	15.2	15.3
1,500.....	168.7	177.4	242.4	251.9	149.0	164.7	92.1	105.8	163.1	175.0
Gain......	—13.9	—14.6	26.7	25.7	—21.8	—24.7	5.6	2.8	—0.8	—2.7
RIVERHEAD SERIES										
None.....	135.8	152.4	108.2	117.4	*154.7	*174.0	162.3	196.3	140.2	160.0
500.......	176.3	187.5	130.6	138.5	147.0	167.0	161.5	197.2	153.8	172.6
Gain......	40.5	35.1	22.4	21.1	—7.7	—7.0	—0.8	0.9	13.6	12.6
1,000.....	203.3	215.0	131.8	139.7	158.8	180.7	157.7	190.8	162.4	181.6
Gain......	27.0	27.5	1.2	1.2	11.8	13.7	—3.8	—6.4	8.6	9.0
1,500.....	238.4	249.9	146.7	155.9	167.1	184.8	151.5	185.3	175.9	194.0
Gain......	35.1	34.9	14.9	16.2	8.3	4.1	—6.2	—5.5	13.5	12.4
BAITING HOLLOW SERIES										
None.....	294.2	303.4	35.7	56.4	......	......	108.2	129.5	‡146.0	‡163.1
500.......	300.3	309.9	47.7	69.0	......	......	†108.2	†129.8	‡152.1	‡169.6
Gain......	6.1	6.5	12.0	12.6	......	......	.0	0.3	6.1	6.5
1,000.....	291.1	300.0	51.0	69.8	......	......	107.5	128.8	‡149.9	‡166.2
Gain......	—9.2	—9.9	3.3	0.8	......	......	—0.7	—1.0	—2.2	—3.4
1,500.....	275.0	285.5	69.3	92.8	......	......	116.5	138.5	‡153.6	‡172.3
Gain......	—16.1	—14.5	18.3	23.0	......	......	9.0	9.7	3.7	6.1
AVERAGES OF THREE SERIES										
None.....	187.0	199.3	111.8	125.4	§143.5	§160.4	107.7	130.2	137.7	154.0
500.......	207.2	217.6	131.1	144.5	157.3	§175.0	113.6	137.3	151.5	168.2
Gain......	20.2	18.3	19.3	19.1	13.8	14.6	6.1	7.1	13.2	14.2
1,000.....	225.7	235.7	132.8	145.2	§164.8	§185.1	117.2	140.9	158.7	172.2
Gain......	18.5	18.1	1.7	0.7	7.5	10.1	3.6	2.6	7.2	4.0
1,500.....	227.4	236.6	152.8	166.9	§158.0	§174.8	120.0	143.2	164.2	180.4
Gain......	1.7	0.9	20.0	21.7	—6.8	—10.3	3.8	2.3	5.5	8.2

* On this series of plats (Riverhead, 1907), as will be seen by referring to the footnote of Table I, Plat 14 was considered a check instead of Plat 8, owing to lack of room. This was an unfortunate selection, since growth of crops and yields showed some factor, aside from those in the tests, increasing the yields on the duplicate Plats 9-14 (really 8-13) over the first group, Plats 2-7, so that the average of check plats 1 and 14 is too great. Plats 9 and 10 (really 8 and 9) outyielded their duplicates, 2 and 3, by 10 bushels to the acre. If we use a second check correspondingly greater than Plat 1, we would have an average yield on the check plats of 145.3 bushels large potatoes and a gain for 500 pounds of fertilizer of 1.7 bushels instead of a loss of 7.7 bushels. This change would raise the average gain at Riverhead for 500 pounds of fertilizer as shown in the fourth section of the table to 18.5 bushels of large potatoes instead of 13.8 bushels; and the general average gain for all the tests to 14.4 bushels instead of 13.2 bushels. The remaining comparisons would not be changed since the yield of two plats with each quantity of fertilizer serve as checks for the next increase of 500 pounds.

† Average of two plats only. ‡ Average of three years only. § Average of two series only.

Table VIII.— Fertilizer vs. No Fertilizer for Potatoes: Incidental Tests.

A. IN COMPARISON ORGANIC AND INORGANIC NITROGEN IN COMBINATION.

Cutchogue Series

Amount of fertilizer to the acre	Acre-yields calculated from plat averages									
	1905		1906		1907		1908		All years	
	Large	Total	Large	Total	Large	Total	Large	Total	Large	Total
Lbs.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
None.....	183.0	191.3	180.2	193.0	154.8	177.5	69.2	80.2	146.8	160.5
1,000.....	221.1	229.8	224.3	234.6	160.1	181.7	91.8	101.0	176.8	186.8
Gain......	38.1	38.5	44.1	41.6	5.3	4.2	21.6	20.8	30.0	26.3
Riverhead Series										
None.....	132.9	155.5	107.3	115.1	178.1	197.6	136.8	172.3	140.3	160.1
1,000.....	212.6	226.2	164.9	174.6	185.7	203.2	151.5	181.7	178.7	196.4
Gain......	73.4	70.7	57.6	59.5	7.6	5.6	14.7	9.4	38.4	36.3
Baiting Hollow Series										
None.....	273.7	293.2	35.4	55.1	......	......	107.7	131.0	138.9	159.8
1,000.....	263.5	278.9	69.3	92.1	......	......	112.2	139.1	148.3	170.0
Gain......	—10.2	—14.3	33.9	37.0	......	......	4.5	8.1	9.4	10.2
Averages of Three Series										
None.....	198.6	213.3	107.6	121.1	166.5	187.6	104.6	127.8	144.3	160.1
1,000.....	232.7	244.9	152.8	166.9	172.9	192.2	118.5	140.6	167.1	184.5
Gain......	34.1	31.6	45.2	45.8	6.4	4.6	13.9	12.8	22.8	24.4

B. IN COMPARISON ORGANIC AND INORGANIC NITROGEN SEPARATELY

Cutchogue Series

None.....	......	......	180.2	193.0	159.3	182.7	69.2	78.8	136.2	151.5
1,000.....	......	......	226.9	239.0	175.4	194.5	88.8	104.3	163.6	179.2
Gain......	......	......	46.7	46.0	16.1	11.8	19.6	25.5	27.4	27.7
Riverhead Series										
None.....	......	......	107.3	115.1	187.3	204.1	129.0	161.8	141.2	160.3
1,000.....	......	......	155.0	162.0	188.5	208.8	132.4	160.3	158.6	177.0
Gain......	......	......	47.7	46.9	1.2	4.7	3.4	—1.5	17.4	16.7
Baiting Hollow Series										
None.....	......	......	35.4	55.1	......	......	104.7	128.2	70.1	91.7
1,000.....	......	......	52.8	76.7	......	......	114.5	140.1	83.6	108.4
Gain......	......	......	17.4	21.6	......	......	9.8	11.9	13.5	17.7
Averages of Three Series										
None.....	......	......	107.6	121.1	173.3	193.4	101.0	122.9	115.8	134.5
1,000.....	......	......	144.9	159.2	182.0	201.7	111.9	134.9	135.3	154.9
Gain......	......	......	37.3	38.1	8.7	8.3	10.9	12.0	19.5	20.4

TABLE IX.— SUMMARY OF INFLUENCE OF QUANTITY OF FERTILIZER ON POTATO YIELDS

PART I. PLANNED TESTS

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

Quantity of fertilizer to the acre	Acre-yield of large potatoes calculated from averages of plats in three series in —				
	1905	1906	1907	1908	All years
Lbs.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
None	133.3	111.8	154.7	80.3	120.0
500	160.7	131.9	147.0	89.6	132.3
Gain	27.4	20.1	—7.7	9.3	12.3
1,000	192.9	132.8	158.8	97.0	145.4
Gain	32.2	0.9	11.8	7.4	13.1
1,500	203.5	152.8	167.1	104.3	156.7
Gain	10.6	20.0	8.3	7.3	11.3

PART II. INCIDENTAL TEST

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.

None	161.1	107.6	178.1	88.4	133.8
1,000	216.8	152.8	185.7	102.0	164.3
Gain	55.7	45.2	7.6	14.6	30.5

PART III. INCIDENTAL TEST B

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

None	......	107.6	187.3	86.9	127.3
1,000	......	144.9	188.5	101.6	145.0
Gain	......	37.3	1.2	14.7	17.7

SUMMARY OF GAIN FOR 1,000 POUNDS OF FERTILIZER TO THE ACRE

(Plats at Baiting Hollow in 1905, Cutchogue in 1907 and Riverhead in 1908 excluded.)

None	147.2	109.0	173.4	85.2	127.0
1,000	204.9	143.5	177.7	100.2	151.6
Gain	57.7	34.5	4.3	15.0	24.6

secured. In this year the use of 1000 lbs. of fertilizer in the "methods" tests gave an average gain of 59.6 bu., and in the "form of nitrogen" test of 55.7 bu. In this year, however, 500 lbs. added to the 1000-lb. application gave an increase of only 10.6 bu., an unprofitable return.

SUGGESTIONS BASED ON FIELD OBSERVATIONS

Wherever stable manure or barnyard refuse is to be used for potatoes or when sod is to be turned under for this crop, plowing should be done early in the fall and some cover crop sown to prevent winter washing and drifting of the soil.

Our experience and observation have shown that uncomposted manures or sod plowed under in the spring is of little or no value for early planted potatoes; and Long Island growers always plant both early and late potatoes early. In case of severe drought, plowing under coarse manure or tough sod may result in actual injury to the crop.

Another factor that must be considered is drought; for the east end of Long Island very rarely escapes a dry period in July or August. To meet these droughts the grower must keep his soil for potatoes as well supplied as possible with well rotted humus to retain winter and spring rains, must plant early and use quick-acting fertilizers.

It is our opinion, based on nearly fourteen years' observation, that these annual drought periods are the principal factor influencing results; so that small amounts of fertilizer give better returns than larger quantities. Hence, as long as the grower cannot control the water supply for his crop he is wasting funds and labor in the use of large quantities of fertilizer to grow a potato crop.

CONCLUSIONS

The only conclusion that can be drawn from a study of these data, of practical value to the potato growers of Long Island, is that, during dry seasons, soil and climatic conditions are of far greater importance than the method of applying fertilizers, differences in the form of nitrogen used or the quantity of fertilizer applied. Failure to provide for a supply of humus to assist in retaining the moisture in these light soils, or to conserve moisture by cultivation will neutralize any beneficial effects that might come, on heavier soils or in moister seasons, from differences in fertilization such as were compared in these tests.

The indications, though slight, favor putting the fertilizer in the drill rather than applying it broadcast if the cost of handling in this way is equal to or less than that of broadcasting. The data also show that amounts of high-grade fertilizer up to 1000 lbs. to the acre will give profitable returns in good potato years; but that more than 1000 lbs. is seldom justified.

The form of nitrogen is apparently immaterial though, on general principles, it would seem best to have part organic and part inorganic if the difference in cost of the two forms is slight; and field observations showed that where potatoes were planted early in soil with good water-holding properties and the moisture was carefully utilized the use of inorganic nitrogen produced a much quicker and more rapid growth of vine than did the organic. Furthermore, the fact that this form of nitrogen costs less than the organic nitrogen will make it advisable to continue the use of one-half organic nitrogen and one-half inorganic in potato-fertilizer formulas.

REPORT

OF THE

Department of Horticulture.

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REPORT OF THE DEPARTMENT OF HORTICULTURE.

PRUNING FRUIT TREES.*

Pruning when transplanting.— We are ready to set the tree and the problem of pruning is before us. It is necessary to cut away part of the branches to enable the injured root system to supply the remaining branches with water. The less the roots are injured the less the top need be cut away. Both theory and experience lead to the belief that fruit growers usually make a mistake in the manner of pruning newly set trees. The common way is to cut back all of the branches.. This, in many cases, is wrong. The top buds on a branch develop soonest and produce the largest leaves. Now a newly set tree will grow best if it can develop a large leaf surface before dry, hot weather sets in, and this it will do if some branches are left intact. Therefore, instead of shortening-in all branches, cut away some of the branches entirely. The tree so pruned will start growth and acquire vigor more quickly and a better top can be formed. There are some cases in which certain fruits or varieties produce abnormally long branches by the end of the second year which may have to be cut back.

The first pruning.— With a one year old tree pruning is easy. Remove the branches and cut back the remaining whip to the heading height desired. The reason for this cutting back is that a tree of this age has not sufficient space of bare trunk between the branches for final branch spacing. If the tree is two years old, as is usually the case with all fruits excepting the peach, or when the one year old plants have been set a year, the real work of heading may be begun, but even now the required space for proper heading hardly exists, and the head cannot yet be wholly formed. This early pruning is, therefore, all more or less provisional though an ideal for the future tree must be plainly in the mind from the start.

* A reprint of Circular No. 13.

The height of the head.— A decisive choice must be made at the very start as to the height of the head. Shall the tree be low or high-headed? The choice should usually be for a low-headed tree for the reason that such a tree is more easily sprayed and pruned and the fruit more readily thinned and harvested. Crop and tree are less subject to injury by wind; the trunk is less liable to injury by sunscald, winter-killing and parasites; the top is more quickly formed and the low-headed tree soonest bears fruit. No advantage as to cultivation is gained by either method over the other, as a well trained tree with a low head, in which the branches ascend obliquely, permits the cultivator to come sufficiently near the tree. It is a fact, for which no explanation can be offered here, that the branches of low-headed trees ascend more uprightly than those of trees headed high. By low-headed is meant a distance from earth to the first limb of from one to two feet. The peach may be headed at the lower distance, the plum, pear and cherry somewhat higher, while the apple should approach the upper limit.

The form of the top.— Two general types of top are open to choice; the vase form or open-centered tree, and the globe or close-centered tree. In the first the frame-work of the tree consists of a short trunk surmounted by four or five main branches ascending obliquely. In the close-centered tree the trunk is continued above the branches, forming the center of the tree. There are several modifications of each of these. In this climate the open-headed, vase-formed tree is best for the peach and the close-centered two-storied tree is best for all other fruits. Whatever the form, care should be taken that the lowest branches are longest so that the greatest possible leaf-surface will be exposed to the sun and light.

Tree formation.— For several years after planting, the peach alone excepted, fruit trees need to be pruned only to train the tree. Just how much to prune young trees depends upon the fruit, the variety, the soil and the climate. Fruit growers prune trees far too much, thereby increasing the growth of wood and of leaf surface and delaying the fruiting of the plant. If trees

were originally well selected all that is needed is to remove an occasional branch which starts out in the wrong place — the sooner done the better — and to take out dead, injured or crossed limbs. The peach, some plums and some pears may need heading-in, and a weak or sickly tree may require somewhat more severe pruning.

Pruning for wood.— When the head of the tree is formed subsequent pruning is directed toward the formation of wood or of fruit-buds. If a tree is bearing many small fruits, if the top contains dead or dying branches, or if the seasonal growth is short and scant, it may be taken for granted that the tree lacks vigor, or, in old trees, is passing into decrepitude. Such trees may usually be rejuvenated by judicious pruning. In professional terms the tree must be "pruned for wood." Such pruning consists of cutting back a considerable number of branches and in wholly removing others. The practice is based upon the fact that the development of leaves and shoots — vegetative activity — is dependent upon a constant supply of the soluble nutriment — the sap. Therefore, when the size of the tree-top is diminished the remaining parts grow more lustily. If half of the top of a decrepit tree is cut away, the remaining half in the season that follows will produce a leaf surface often twice that which the whole top would have borne. When trees are enfeebled by age, injured by insects or fungi, robbed of food moisture by sod or crops, or neglected in any way, there is nothing which will more quickly stimulate them and renew their youthful vigor than conservative surgery. Such pruning should usually be extended over two or more years. In pruning for wood the following rules are usually applicable:

Weak-growing varieties may always be pruned generously; strong-growing kinds, lightly.

Varieties which branch freely need little pruning. Those having unbranching limbs should be pruned closely.

In cool, damp climates trees run to wood and need little pruning. In hot, dry climates they need much pruning.

Rich, deep soils favor growth; prune trees in such soils lightly.

In shallow, sandy soils, trees produce short shoots, and the wood should be closely cut.

Pruning for fruit.— A barren tree can sometimes be made to bear fruit by proper pruning. Not infrequently barrenness is caused by over-manuring or over-stimulation of some kind, because of which the number of shoots and leaves and the size of the same are greatly increased, but flower buds do not form. This over-production of wood and leaf can sometimes be stopped by breaking or cutting off the greater portion of the season's growth in late summer. The philosophy of such pruning is that in taking away the greater part of these growing shoots we deprive the tree of the parts which are making greatest demands upon the nutritive powers of the plant, and this permits the lower buds to enlarge and store up more reserve food, a condition necessary to the formation of fruit-buds. Summer pruning is a weakening process and in our climate may greatly decrease the vigor of the plants if frequently resorted to. The practice is neither common nor often necessary in this State except in the case of dwarf apples and pears.

Summer pruning must be done when the elongation of shoots has ceased for the season. The time cannot be stated definitely but in this climate it is about the first of August. Emphasis must be put upon the fact that this pruning should not be done at a fixed time; *all* depends upon the season. If the tree is pruned too early the shoots cut back start growth and the operation has been useless or worse than useless, for this second growth not only prevents the object desired but is harmful. On the other hand, if the pruning is too late there is not sufficient time for the food material to accumulate for the proper production of fruit buds. In our inequable climate it is very difficult to practice summer pruning successfully, and it is probably best, instead of cutting off the ends of the young shoots, to break them off and let them hang, cutting them in the winter. Such breaking is an aid in preventing second growths. Usually in this operation at least half of the young growth should be removed. In closing the topic it must again be said that summer pruning is a matter of special resort.

The habit of the tree.— In pruning, one must consider well the habit of the tree. When trees have a spreading, drooping or long, slender habit of growth, prune to buds that point upward or to the center of the plant. If the habit be upright and dense, cut to lower or outer buds and so spread the compact top. The "off year" habit of bearing is intensified by spasmodic and severe pruning. Prune biennial bearers rather conservatively and yearly. If heavy pruning is decided upon with such varieties prune before the fruiting year rather than before the "off" season. The experiment may be tried of pruning only before the fruiting season as a means of correcting over-bearing and alternate bearing, faults which usually go together. The heads of all young trees may be left fairly dense, for when the trees come in bearing the weight of the crop opens the head; meanwhile by saving the foliage you have obtained a larger trunk and more bearing wood.

Heading-in.— Heading-in makes the top of a tree thicker and broader. There are but few orchards or even trees that do not need more or less heading-in at some time in their history. But in our climate this form of pruning is practiced only with peaches and some plums, and is but little needed with other fruits unless it is summer heading-in described before. In winter pruning the cutting back of exceedingly long branches or the thickening of the top of occasional trees or varieties is the exception rather than the rule. The sheared, clipped and trimmed trees that are often seen in gardens are usually the work of men who have learned to prune in Europe and have failed to adapt themselves to the wholly different American conditions. Since heading-in is usually practiced to reduce extensive growth it is always best to consider if there is not some way of preventing too much growth, as, through withholding fertilizers, not pruning in winter, or by use of cover crops. In other words, it is better not to force trees than to force them to produce too much wood and then cut it off. Peaches and some plums bear fruit on the wood of the past season. The crop is borne progressively away from the trunk. It is necessary to head-in these fruits to keep the bearing wood near the trunk. Apples, pears, most plums, and cherries are borne on

spurs from wood two or more years old, and, therefore, with these heading-in is not a regular practice.

Suckers.— When a tree on the decline is severely pruned a growth of long, vertical shoots with few leaves often follows. These are suckers or water sprouts and since the sparseness of foliage prevents the shoots from elaborating food they appropriate it from the parts upon which they grow. Suckers are therefore robbers, true parasites, and should be removed whenever and wherever found. Occasionally they may be used in the development of normal branches, though their value for this purpose is small. Suckers may arise from over-manuring or other causes which upset the equilibrium of the tree.

Dehorning trees.— A great deal is said about dehorning trees. By dehorning is meant the cutting back of all branches to within two feet or even less of the trunk. The term in use for this rather severe operation is a misnomer, for the tree so treated is really decapitated. If cutting off the top of a tree is "dehorning" one can as well say that cutting off the roots is "detailing." Most trees that are "dehorned" may as well be "detailed" at the same time. There are, however, exceptional cases with peaches and possibly other stone fruits, when this wholesale renewing of the top is rational, as when good trees of these fruits in their prime are severely injured by over-bearing, heavy winds, snows, fungi, or other causes. But to "dehorn" peach trees fifteen or more years old for the sake of one more crop is usually a very poor practice. Such trees in most cases should go to the brush heap and a young orchard take the place of the old.

Root pruning.— Root pruning is seldom necessary in American orcharding. In cooler, damper climates it is of some value in dwarfing trees and in bringing them into fruit. To prune the roots is to cut off the food supply and thereby starve the tree. This drastic treatment is sometimes recommended for the orchards of this region, but it is extremely doubtful if properly pruning the top, good tillage or less severe measures than cutting the roots will not bring about the same results without permanently weakening the trees as does root pruning. This applies to pruning the

roots of mature trees and not to the fantastic notion set forth by Stringfellow some ten or twelve years ago that young trees are best transplanted by cutting the roots back to a stub. Until nature reverses the laws of plant-growth, tree planters had much better continue setting trees with a root system ready to perform its function naturally and normally, even though a plant pruned to a stub may grow, and under exceptional conditions may grow well.

The work of pruning.— Each man must select his own pruning paraphernalia — as ladders, knives, saws and shears. Occasionally you see a man pruning with an ax. Now an ax is a good tool for some purposes but it is not of much value in pruning. A sharp knife in the hands of an expert is a better tool than shears, but the amateur had much better stick to shears.

The cut in pruning should always be made parallel with the trunk and as close as possible. One of the most elementary rules of pruning is that the cut should be made just beyond a healthy lateral branch, and yet in the average orchard the rule is violated more often than it is followed. The reason for so cutting is plain. The lateral branch is stimulated to produce a great number of leaves which assimilate sap. This elaborated food passes back through the inner bark near the newly-made cut and the wound quickly callouses and heals because it thus has access to an abundant supply of food.

The notion prevails that a wound of any size will heal, but the majority of wounds over three inches in diameter do not heal — decay sets in, followed by wood-destroying fungi, and these, with the action of the weather, are followed by rotten wood, a hollow branch and a diseased tree. The Geneva Station is now digging out an apple orchard in which the centers of the trees were removed some fifteen or eighteen years ago. The trees might have borne crops for two or threee decades longer, but practically all are worthless from the results of the cutting out of large limbs. The life of a tree is endangered whenever a large branch is removed, and such an amputation should be made only under dire

necessity. Tree lovers shudder at the ghastly wounds and mutilated trees in the average orchard. The professional "hewers of wood" who call themselves "tree pruners" are responsible for much of the dreadful slaughter seen in orchards.

It is presumed that every fruit-grower has learned from observation or experience that one of the secrets of the healing of large wounds is to cut close to the trunk, and no matter how large a wound may be it is better than leaving a projecting stub. The chances for healing with a large wound are materially increased by a coating of thick lead paint to protect the cut surface from evaporation and moisture. It is a waste of time to treat wounds less than two inches in diameter.

Pruning of often left to "time and chance" but there is a best time, which is late winter before the sap flows. The objection to early winter pruning is that there may be injury to the tissues near the wound from cold or from checking. The objection to late spring is to the loss of sap and because the fluids run down the bark and keep it wet and sticky, making a suitable place for the spores of various rot fungi so that decay may set in. But in practice it is often found necessary to prune from the time leaves drop until they are well started in the spring.

It may be helpful to the beginner in fruit-growing to remember that: 1st, Pruning is an art learned only in the practice of it. 2nd, Pruning is a work in which quickness is good but haste is bad. 3d, Almost any method well carried out year by year is better than alternate pruning and neglect. 4th, Like children, trees should have their faults corrected early. 5th, One can cut in a minute from a tree what years cannot reproduce. 6th, Each cut of the pruning knife should be in accord with a definite purpose. 7th, Do not remove useful limbs because the head is unbalanced. Time will likely restore the balance. 8th, Do not attempt to prune as much as you can from a tree, but see how much wood can be left without detriment to the tree.

U. P. HEDRICK.

Geneva, N. Y., Jan. 15, 1910.

SMALL FRUITS: MANAGEMENT AND VARIETIES.*

The small fruit business is not a small business — it is intensive farming, with methods more exacting than in general agriculture. The greatest results are never secured by half-way measures; and no mere study of lists of varieties, guides to planting, directions for management or discussions of enemies to be met will make a successful grower out of a novice. Suitable climate, soil, culture, markets are not sufficient. The personality of the man puts its stamp upon the business; it is the mind directing the operations of fruit-growing that effects final results.

Occasional failures or partial losses always occur; yet it is seldom that all the Small Fruits fail in any one season, and for this reason some find a decided advantage in a variety of the fruits that may be grown, such as strawberries, red and black raspberries, blackberries, currants or gooseberries.

Location.— Some attention must be paid to the location. Occasionally it is impossible on account of uniformity in type of soil or of slope to make much selection. It is usually the case, however, that some parts of the farm are better adapted to one fruit than to another. The most suitable location, as a rule, is one sufficiently elevated above adjoining lands to be free from danger of serious late spring or early fall frosts caused by the tendency of cold air to settle in the lowest areas. A slight slope also simplifies questions of drainage, and, in addition to this, permits the planting of varieties liable to be injured by frost on the higher elevation.

Exposure, or direction of slope.— A southerly slope and a light, sandy soil warm up quickly and tend to hasten maturity, while a northerly slope and a heavier soil are colder and tend to retard maturity. Where early markets are most profitable the former conditions should be chosen; but where late berries are in demand, the colder soil should be selected.

* A reprint of Circular No. 14.

Tillage.— Until we understand the importance of tillage, preparation of the land and subsequent cultivations will too frequently be neglected. Many growers are guided in the number of cultivations by the unsightly appearance of weeds, and in a dry season which is unfavorable for their growth cultivation frequently ceases in part or altogether; whereas such a time is the one season of the year during which the greatest good may be secured by frequent cultivation — mostly shallow with small fruits, but sufficiently deep to insure an efficient dust mulch.

Tillage is one of the cheapest and most efficient agents in setting free unavailable plant food, and in hastening decomposition of organic matter. But of greater importance than this is the relation of tillage to the water supply. An abundance of food without moisture to carry it into solution is of no use to the berry plant; by an extensive operation of tillage, not only is the water-holding capacity of the soil increased but evaporation from the surface is checked and the moisture becomes of use to the plant.

The roots of berry plants do not extend far as compared with those of tree fruits, and this fact increases the importance of this phase of the subject. The surface soil quickly loses moisture and the shallow root systems of the strawberry, the currant and the gooseberry are injured in droughts which have no effect upon the apple or the pear. This question of moisture is always a serious one to the small fruit grower. The crop may be carefully nursed for weeks up to the season of maturity of the fruit, and a week of dry weather may reduee the yield from one-quarter to one-half. Not only is the crop harvested largely composed of water, but in producing large yields in a short time, as small fruit do, great quantities of water must pass through the plants.

Of all small fruits the strawberry is most quickly injured by drought; nearly all the roots are within the upper 15 inches of soil — a limited space, and are quickly affected during the fruiting season by a few days of dry weather. The average rainfall is not sufficient to mature the crop without some effort to conserve moisture by cultivation or by mulching. Scarcely a season passes,

and 1909 was no exception, but that one or more of the small fruits is reduced in yield from 25 to 75 per ct. because of lack of moisture. At the Geneva Station the total rainfall during the months of June, July, August and September in 1909 was but 8.64 inches, much too small an amount for normal yields. Even with good cultivation the crops suffered; without it the small fruits would have been complete failures.

Fertilizers.— There is no one brand of fertilizer best suited for strawberries, another for raspberries, or for blackberries, or for the other small fruit. The kind and amount to use depend largely upon the kind, amount and availability of the fertility already in the soil. No chemical analysis can determine all these points; so soil analyses made in a laboratory are usually of no help to the crop grower. The chemist can tell what is in the soil and how much, but he cannot determine how much of this is available to the plant or how rapidly the plant may use such food. Some soils may lack nitrogen, others potash or phosphoric acid, and many are deficient in humus, or a soil supplied with all these may still be unproductive because of unfavorable soil texture or bad drainage, under which conditions fertilizers will be of but little use. The best method of determining the kind and amount to use is by trial, leaving check rows for comparison. If the soil responds to phosphoric acid, applications of fertilizers rich in this form of plant food should be made, and so with potash or nitrogen. Possibly a combination of two foods may meet the needs of the soil, or perhaps a complete fertilizer may be found most suitable. These fertilizing materials should be applied in such a way as to make comparisons with each other and with checks to which nothing has been applied. It is more difficult to use cover crops among small fruits than with tree fruits, yet they may at times be used to advantage and when combined with the use of stable manure may do much to keep up the supply of humus.

Distance of planting.— In general, the plants should not be crowded. There should be ample room for each plant to secure its share of food and moisture from the soil, and air and sunlight

should not be shut out from the growth above ground. Red raspberries may be set closer than black raspberries, six or seven feet by two feet, and blackberries still farther apart; currants and gooseberries four and one-half to six feet apart, and strawberries the closest of any of the small fruits.

Pruning.— The operations of pruning are not so difficult as with tree fruits, yet some attention must be given to this subject. The old canes of raspberries and blackberries are of no further use after the fruit has been harvested. They frequently harbor insects and diseases as well as crowding and shading the new growth. For these reasons the practice is followed among many growers of cutting out and burning the old wood as soon as the fruit has been harvested. The pruning of currants and gooseberries consists in keeping the head well open and in removing some of the oldest wood each year after the bushes reach maturity as the best fruit is secured from the younger wood.

Protection of plants.— The development of the fruit bears a close relationship to the health of the plant. Insects and fungus troubles weaken the plants and should be controlled wherever this can be done economically. Spraying with bordeaux mixture and an arsenical poison is effective in keeping down currant worms and in holding the foliage of currants and gooseberries in late fall. A single application when the first worms appear is the usual treatment. Unfortunately no satisfactory remedies have as yet been found for certain diseases such as orange rust of blackberries or anthracnose of black raspberries, and in such cases prompt measures should be taken to dig and burn infested plants, or to practice a system of frequent plantings of healthy stock, giving the best of care to secure a vigorous and well developed growth. It is usually not profitable to spray strawberries.

Winter protection is desirable and even essential with some of the small fruits. Strawberries should be covered with some material that will give protection against freezing and thawing, and at the same time not smother the plants. A few tender varieties of raspberries and blackberries must be laid down and

be protected with old mulching and soil to avoid serious killing back of the canes.

Selection of varieties.— Small fruit varieties are remarkably subject to the influences surrounding them, so much care should be exercised in selecting those suited to the grower's particular conditions. Varieties best adapted to one set of conditions may be failures elsewhere. Lists of varieties are almost always unsatisfactory. Only those varieties should be extensively planted that have by actual trial shown their fitness for the location. One of the most valuable places on any small fruit farm is its test plat in which is being grown on a small scale the newer and apparently more promising varieties that have not as yet shown their value. In the selection of varities some attention must also be given to the market supplied. Varieties suited for one purpose may be useless for something else, and the object in growing must be kept in mind, whether for dessert, canning, local or distant markets or for evaporating. The variety selected should have those qualities which recommend it most strongly for the special purpose in view. Many of the kinds grown twenty-five years ago have been discarded and it is to be expected that many of the kinds grown at the present time will be on the retired list in the next quarter century. New varieties are receiving recognition each year. The progressive grower should not hasten to discard his standard varieties for something new and untried, but should be ready to introduce into his test plat those that appear to possess superior merit.

The following lists of varieties are suggestive. They include many standard kinds and also some of the newer varieties which appear to be worthy of more extended trial.

STRAWBERRIES

Early:

Abington.— Per: Very productive; large, light scarlet; worthy of trial.

Beder Wood.— Per: Standard; not large size or of highest quality; productive.

Golden Gate.— Semi-Per: Very productive; many qualities to commend it.

Highland.— Imp: Light scarlet, sprightly. Good size; worthy of test.

MIDSEASON:

Amanda.— Per: Blooms late, large, retains size well; worthy of trial.

Bubach.— Imp: Rather large, not very firm; standard in certain localities.

Carrie Silvers.— Imp: Large; retains size; attractive color.

Chesapeake.— Per: Few runners; large, glossy scarlet; worthy of trial.

Glen Mary.— Per: Standard; does not succeed on all soils.

Good Luck.— Per: Medium number plants; firm, sprightly acid.

Joe.— Per: Few runners; large, attractive, high quality.

Magnus.— Imp: Medium productive. Excellent size and quality. Test for home use.

Marshall.— Per: Standard; dark red; medium productive; high quality.

Prolific.— Per: Productive; large, bright scarlet; one of the best.

Saratoga.— Per: Not always vigorous; dark scarlet; high quality.

Sample.— Imp: Large; excellent color; long season; desirable.

Sen. Dunlap.— Per: Standard; excellent but size decreases in late pickings.

Stahls. — Per: New; promising in size, color and quality; dark scarlet.

LATE:

Blaine.— Per: Plants numerous; fruit retains size well, light scarlet, very good.

Brandywine.— Per: Foliage good; fruit large, dark scarlet; standard.

Cardinal.— Imp: Many desirable qualities; standard in some localities.

Columbia.— Imp: Many runners; very productive; large, light scarlet; worthy of test.

Jessie.— Per: One of the best late, but partial as to soils.

Nettie.— Imp: Plants and berries large; light scarlet, rather acid.

President.— Imp: Of largest size; attractive color; excellent show berry; quality low.

Rough Rider.— Per: Many desirable qualities. One of the best.

Stevens Late Champion.— Per: One of the best late sorts; firm; promising; sprightly; very good.

RED RASPBERRIES

June.— Very early; productive; long season; fruit large; originated at Geneva Experiment Station.

Marlboro.— Early; plants dwarfish; fruit sometimes crumbles.

Pomona.— Early; fruit large; unproductive on some soils.

Cuthbert.— Late: most popular throughout the state: season long.

Herbert.— Late; slightly larger and softer than Cuthbert.

Loudon.— Late; plants semi-dwarf; very productive.

BLACK RASPBERRIES

Eureka.— Early; good size and color; standard; not of highest quality.

Palmer.— Early; unusually long season; not large but desirable on account of earliness.

Cumberland.— Midseason; standard; large, well-colored; desirable.
Diamond.— Midseason; very productive; partial to localities.
Gregg.— Midseason; large; lacks productiveness; high quality.
Hilborn.— Midseason; sweet; well-flavored; desirable.
Mills.— Late; standard; dull black; heavy bloom; plants vigorous.
Onondaga.— Late; hardy, vigorous; large, good color, firm.

PURPLE RASPBERRIES

Columbian.— Late; vigorous, productive; firm, dark purple; persistent.
Shaffer.— Late; fruit larger but softer than Columbian; high quality; excellent for canning.

BLACKBERRIES

Agawam.— Medium early; long season; hardy, very productive; medium size.
Eldorado.— Medium early; hardy; large fruit; desirable.
Snyder.— Midseason; unusually hardy; cosmopolitan; berries small.
Ancient Briton.— Late; very productive; mild, high quality; medium size.
Chautauqua.— Late; vigorous; large, sprightly; promising.
Mersereau.— Late; not always hardy; large; desirable.
New Rochelle.— Late; old variety; unusually hardy; vigorous; desirable.

RED CURRANTS

Cherry.— Large; clusters short; productive; standard.
Fay.— Sprawling habit of bush; large; medium productive.
Filler.— Productive; bunches shorter than Red Dutch or Victoria but larger in berry.
Perfection.— Superior to Fay or Cherry in flavor; bush more upright than Fay; desirable.
Red Cross.— Large; milder and slightly later than Cherry.
Red Dutch.— Habit of growth good; sprightly acid; dark red; medium size.
Wilder.— Good late variety; vigorous; fruit large; long season; standard.

WHITE CURRANTS

White Imperial.— One of the most desirable kinds; mild, excellent flavor; dessert.
White Grape.— Large and well colored; medium quality.

BLACK CURRANTS

Champion.— Mild, nearly sweet; desirable.
Prince of Wales.— Very productive; mild; sweet; vigorous.

AMERICAN GOOSEBERRIES

Downing.— Standard; pale green; excellent flavor and quality; one of the best.

Red Jacket.— Pale red; very vigorous; large; productive.

Pearl.— Resembles Downing but less productive.

Smith.— Dull, pale green, sometimes spotted red, nearly as large as Downing.

EUROPEAN GOOSEBERRIES

Chautauqua.— Pale green; excellent flavor and quality.

Columbus.— Very vigorous; nearly white; sweet; desirable.

Dominion.— Greenish white; later and larger than Whitesmith; seldom mildews.

Industry.— Very productive; dark red; high quality; one of the best.

Triumph.— Pale yellow; large; sweet; desirable.

Whitesmith.— Vigorous; pale yellowish-green; sweeet; very good.

THE PEACH IN NEW YORK.*

Location and soil.— The ideal location for a peach orchard is elevated land near or sloping toward a body of water of suitable extent. The shaly or gravelly slopes about the Great Lakes or the Central Lakes of New York are generally well adapted to the peach. Beside locations near the bodies of water mentioned there are many morainic hills in different parts of the State and much land sloping toward the Hudson River which could be planted to peaches with excellent prospects of success. Elevated, rolling or hilly lands are good peach lands because they are usually naturally well drained and because there is less danger of winter injury and the blossoms escape the late spring frosts which are so disastrous to the peach crop in less well favored locations. The peach will thrive upon a great diversity of soils, provided two conditions be ever present — good drainage and soil warmth. All know that the peach grows well on well drained soil, but few realize the importance of soil warmth for this fruit. It is chiefly because sandy, gravelly and stony soils are warm that the peach is grown thereon. Upon such soils the trees make a firm growth, the wood matures thoroughly and the fruit is highly colored and well flavored.

Fertilizers for peaches.— Consideration of fertilizers for peaches naturally follows a discussion of the soil. The writer is not in accord with most fruit growers in the matter of fertilizers for fruits, and for the peach in particular. In his opinion much of the commercial fertilizer applied to tree fruits is wasted. This opinion has been expressed in meetings of New York fruit growers, but since it does not meet general approval in all quarters and since the writer is more than ever convinced that fertilizers are wasted, not wholly but in too great a proportion, in fruit-growing, it is worth going over the matter again.

From theoretical consideration fruits need comparatively little plant food, because:— From eighty to ninety per ct. of the fruit

* A reprint of Circular No. 15.

crop is water; the food used in the foliage is largely returned to the soil; trees have a feeding and growing period of several years before they bear fruit; the growing season for trees is long —from early spring until late fall; the roots of trees go deep and spread far into the soil; trees transpire relatively large amounts of water and hence diluted solutions of plant food may suffice to furnish food; nearly all trees have "off years" of bearing in which to recuperate.

Experiments in various parts of this State confirm the hypothesis that tree fruits need less food than agricultural, truck and small-fruit crops in general, and every observing man has seen good fruits of the several kinds grown on soil too poor to make good farming lands. The peach, in particular, is to be found thriving on soils so sandy, gravelly or stony that it is difficult to secure a good catch of even such cover crops as oats or rye. Nitrogen in particular is not often needed in peach orchards. In concluding this topic let it be plain to all that it does not follow from the above statements that the peach never needs fertilizers. To the contrary peach trees are often benefited by additions of plant food. The important fact is that this and all other fruits must be given fertilizers with exceedingly great care if it is to be done without waste. A fruit grower ought to experiment very carefully and know that he is getting the worth of his money before he uses any considerable quantity of fertilizer on his trees.

Moisture for peaches.—A far more important factor than food, for the peach or for any fruit in this State, is drink. Liebig's "law of the minimum," according to which the yield of any crop is limited by the amount of one constituent of food, is now applied to all of the factors affecting the growth of plants. When applied to the fruits of this State it will be usually found that water is the limiting factor. I cannot do better than to quote several authorities as to the importance of moisture in growing crops. King[1] states: "There are very few fields upon which

[1] Physics of Agriculture, p. 181. By F. H. King. Madison, Wisconsin: 1901.

crops of any kind, in any climate, can be brought to maturity with the maximum yields the soils are capable of producing without adopting means of saving the moisture." Hilgard[1] holds that under ordinary conditions of culture, and within limits varying for different soils and crops, production is almost directly proportional to the water supply during the period of active vegetation. Whitney[2] claims that the moisture supply in the soil is the only important factor to be regulated by the cultivator in most soils, all other factors being, in general, provided for naturally. A generation ago Johnson[3] wrote: "It is a well recognized fact that next to temperature, the water supply is the most influential factor in the product of a crop. Poor soils give good crops in season of plentiful and well distributed rain or when skilfully irrigated, but insufficient moisture in the soil is an evil that no supplies of plant-food can neutralize."

The trend of this discussion is obvious. The peach grower must use all possible means to provide water for his trees in the dry summer months. After having selected land naturally retentive of moisture or having a supply in the subsoil, making sure that the drainage is good, all that can be done is: 1st. Supply organic matter to make the soil more capable of holding water. 2nd. By continuous cultivation conserve as far as possible the rainfall.

Cultivation.— However men may differ as regards cultivation for the apple, few will deny the absolute necessity of it for the peach. Uncultivated apples in western New York, as a rule, are bad enough, but an untilled peach orchard is the desolation of desolations. Show me a man who says "peaches don't pay" and nine times out of ten I can show you a sod-bound orchard — the trees sick with "sod-yellows," cursed with borers and other insects and thirsting for the water which goes to the grass. Never put the peach out to grass. Never! Never! Never! Nor sow the orchard to grain; nor intercrop after the trees come in bearing.

1 Soils, p. 193. By E. W. Hilgard. New York: 1906.

2 U. S. Dept. Agr., Bureau of Soils, Bul. 22, 1903.

3 Hows Crops Feed, p. 216. By Samuel W. Johnson. New York: 1870.

Plow in the spring, cultivate the surface soil until the middle of August, and follow with a cover crop to be plowed under the next spring.

Hardiness in peaches.— Possibly the greatest problem the peach-grower has to face is how to avoid or check injury from freezes and frosts. The problem is not insurmountable; for here and there varieties and orchards are wholly uninjured, and possibly adjoining others partly or wholly killed. What conditions of the trees, of the soil, or of the care, make the difference? A few years ago the writer sent several hundred circular letters to peach growers in Michigan and New York asking for information on this subject. The following is a brief summary of the answers: The peach must have a warm, well drained soil to secure the greatest possible hardiness inherent in the species. Either extreme of moisture — excessive wetness or excessive dryness — gives favorable conditions for winter killing. Young trees suffer most in severe winter freezes. The wood of some varieties is more succulent than that of others, making such sorts susceptible to cold. Early and Late Crawford are most succulent in growth, while Chair Choice, St. John, Niagara and Surprise are less succulent. The small-growing varieties with compact heads are hardier than the free-growing sorts with large heads. The following are the most compact growers: Hill Chili, Crosby, Gold Drop, Barnard, Triumph, Wager and Fitzgerald. Trees are more likely to suffer from cold if unthrifty than if thrifty. Late fall growths are very susceptible to winter injury in both wood and bud. Peach growers in the two states hold that the most effective treatment of their orchards to avoid winter injury is to sow cover crops, holding that they protect the roots from cold, cause the trees to ripen thoroughly, and assist in regulating the supply of moisture. Nearly all growers in both states prefer low-headed trees, claiming that both buds and branches are more often injured in high-headed trees. The testimony secured was for most part unfavorable to windbreaks.

The five varieties of peaches most hardy in wood are: Crosby, Hill Chili, Stevens Rareripe, Gold Drop and Elberta. The

Crawfords are considered most tender in wood. The five varities of peaches most hardy in bud are Crosby, Hill Chili, Triumph, Gold Drop and Stevens Rareripe. The five most tender in bud are the two Crawfords, Chair Choice, Reeves Favorite and Elberta.

Leaf curl, yellows and little peach.— It was not long ago that men's hearts were frozen by fear of giants, dragons, hobgoblins and witches. These were big things; but now, in all that has to do with life, it is the little things that give us fright — tiny insects and bacteria, many of them too small for the unaided eye to see. These parasites have created new domains in the agricultural knowledge in which the entomologist, botanist and bacteriologist hold sway and the horticulturist counts for little. Yet I must trespass in the field of the plant pathologist as regards some of the diseases of the peach which are now receiving but little attention.

The first of these is leaf curl, which all know and which all can prevent, for it is one of the easiest of all diseases of fruits to prevent. Yet in the aggregate, the loss to peach growers from leaf curl is enormous. The damage done year in and year out is as great as that from any other peach disease. It is the "white plague" of this fruit. Trees are seldom kelled by the disease, yet it saps their vitality and cuts short their days. Orchard trees and nursery stock alike suffer. Copper sulphate or lime-sulphur sprays in any of their forms for dormant wood easily control leaf curl.

Interest in peach yellows and little peach is revived by a discussion of these and similar troubles of this fruit by Dr. Clinton of the Connecticut Agricultural Experiment Station in the 1908 report of that institution. Clinton holds that these "various troubles are largely the result of the unusual weather conditions that have prevailed during the past seven years." He does not believe that germs and enzyms alone are to be held responsible for yellows and little peach. He suggests as preventive measures against these troubles the following: "1st. Lowlands should be avoided, and as a rule only the higher hills selected, where the

exposure is such as to avoid as much as possible moist winds in winter and early development of the buds in spring. 2nd. Only the best nursery stock should be used, free from all suspicion of winter injury or yellows. 3rd. Care should be used not to force trees too much, especially with late applications of commercial fertilizers. 4th. Frequent cultivation during the first of the season is very desirable, but after midsummer should be discontinued, since late cultivation, like late application of fertilizers, may prevent proper maturity of the wood."

To my mind the precaution of digging out trees affected with yellows and little peach is a very necessary procedure, yet I can most heartily recommend the treatment suggested for these troubles; and, for that matter, all the suggestions apply admirably to peach trees in any condition of health or unhealth.

Pruning.— Of all the tree fruits of this climate the peach requires most attention in pruning. At best it is a short lived tree and if allowed to spend all of its powers of growth each year it soon exhausts itself and dies of old age. Moreover, its habit of bearing is such, the fruit buds being borne on the current year's wood, that unpruned trees soon become unmanageable.

Pruning the peach resolves itself into two distinct problems: First, to increase the vigor of the truee; and second, to train the tree to a form that will make orchard operations easy and give a maximum amount of fruit-bearing wood. It is presumed that a peach grower wants a "merry life and a short one" for his trees, to secure which on sandy soils he must head back. The hardy sorts, nearly all of which are weak in growth, must be pruned much more severely than the stronger growing kinds, which as a rule do not bear nearly so many fruit buds.

The peach does not bear transplanting as well as most fruits. It is necessary, then, in order to prevent excessive evaporation from the top as the plants start, to cut away a large part of the branches — best done by cutting back all branches to the trunk and shortening the remaining whip to from one to two feet. The second year the top must be formed. Two forms of top are open to choice,— the vase form or open-centered tree and the globe-

centered tree. In the first the frame-work of the tree consists of a short trunk surmounted by four or five main branches ascending obliquely. In the second the trunk is continued above the branches, forming the center of the tree, and later, being headed-in, a globe-like head is formed. In our climate the vase form is nearly always chosen. Beginning with the second year the main branches should be shortened back from one-third to one-half their growth, if heading back seem necessary, cutting to upper and inner buds so that the oblique ascending vase form is maintained. The pruning of the third season is much the same, except that some of the interior branches should be removed to open up the heads to air and sunshine. The third season's pruning may be repeated from year to year, bearing in mind that the slow-growing, hardy, productive sorts can be pruned much more severely than the free-growing, tender kinds. Open forks should be carefully avoided, thus greatly lessening the danger of splitting when branches are heavily laden.

These directions have been followed in the main in the pruning of a peach orchard on the Station grounds just coming in bearing. All who have seen the trees so pruned are pleased with them. One mistake was made in pruning this Station plantation — that of cutting out too much wood, thereby inducing an abnormal growth of new wood liable to be injured in a cold winter and making necessary continued pruning for several seasons to come to keep the trees in manageable shape. Our land is heavy and rich. The same amount of pruning on proper land would have done no harm.

Cover crops.—All know the several distinct and valuable purposes which cover crops serve in orchards. They hasten seasonal maturity, protect the tree and soil, add humus and, with legumes, nitrogen to the soil, and modify the physiial structure of the soil. But there is one other function of such crops which I do not believe is often taken into account and one which should appeal especially to those who must buy fertilizers for their trees. Cover crops make available much plant food in the soil. Few fruit growers realize that one may make the cover crop glean from the soil plant food otherwise unavailable and turn it over to the trees.

Why spend money on fertilizers when there are living plants to carry a contribution box to every nook and corner of the soil and to collect wealth from the boundless treasures of nitrogen in the air and turn over the accumulated hoard to the trees! Food and drink, the primal necessities of plants, are supplied to most soils in abundance for trees. They are the capital stock of every farm. The thrifty man will make the most of them.

Thinning the fruit.— It is hardly necessary to mention thinning the fruit for peaches. Each peach grower knows that the best fruit, or even good fruit, can be grown only by thinning. The peaches are thinned to stand four or five inches apart and the work is done as soon as possible after the "June drop" is over. I am sure that all peach growers mean to thin but it is the operation in peach-growing about which growers are most careless, both as to whether it be done and in the manner of doing it.

Varieties.— The varieties of peaches are many, not less than 1,000 named kinds having been grown in the United States since the industry began. The collection of varieties on the grounds of this Station numbers over 300. Of this great number not more than a score at most are worth planting in commercial orchards. Of these the following grouped in periods of ripening are most worthy of consideration:

GOOD PEACH VARIETIES IN ORDER OF RIPENING

First Ripening.

Eureka — White-Fleshed
Greensboro — White-Fleshed
Waddell — White-Fleshed

Second Ripening.

Early Rivers — White-Fleshed
Carman — White-Fleshed
Champion — White-Fleshed
Yellow St. John — Yellow-Fleshed
Foster — Yellow-Fleshed
Belle of Georgia — White-Fleshed

Third Ripening.

Capt. Eads — Yellow-Fleshed
Crawford Early — Yellow-Fleshed
Elberta — Yellow-Fleshed
Kalamazoo — Yellow-Fleshed
Old Mixon Free — White-Fleshed

Fourth Ripening.

Chair Choice — Yellow-Fleshed
Fitzgerald — Yellow-Fleshed
Niagara — Yellow-Fleshed
Stevens Rareripe — White-Fleshed
Crawford Late — Yellow-Fleshed

Fifth Ripening.

Crosby — Yellow-Fleshed
Smock — Yellow-Fleshed
Hill Chili — Yellow-Fleshed
Salway — Yellow-Fleshed

INSPECTION WORK.

REPORT OF ANALYSES OF SAMPLES OF FERTILIZERS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1909.*

(The analyses reported in these Bulletins cease to have value long before they could be reprinted in this Report; and are, therefore, omitted.— W. H. JORDAN, *Director.*)

INSPECTION OF FEEDING STUFFS.†

(See note above.— W. H. JORDAN, *Director.*)

* Printed as Bulletin No. 325.
† Printed as Bullein No. 324.

APPENDIX.

I. PERIODICALS RECEIVED BY THE STATION.

II. METEOROLOGICAL RECORDS.

PERIODICALS RECEIVED BY THE STATION.

Acclimitation	Complimentary
Agricoltura Alessandrina	Complimentary
Agricultural Epitomist	Complimentary
Agricultural Gazette of New South Wales	Complimentary
Agricultural Journal and Mining Records (Natal)	Complimentary
Agricultural Journal of the Cape of Good Hope	Complimentary
Agricultural Ledger	Complimentary
Agricultural News	Complimentary
Allegan Gazette	Complimentary
American Agriculturist	Subscription
American Breeders' Magazine	Subscription
American Chemical Journal	Subscription
American Chemical Society, Journal	Subscription
American Cultivator	Complimentary
American Entomological Society, Transactions	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Grocer	Complimentary
American Hay, Flour and Feed Journal	Complimentary
American Journal of Physiology	Subscription
American Miller	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings	Complimentary
American Poultry Advocate	Complimentary
American Review of Tropical Agriculture	Complimentary
American Stock Keeper	Complimentary
American Sugar Industry and Beet Sugar Gazette	Complimentary
Analyst	Subscription
Annales de l'Institut Pasteur	Subscription
Annales de la Societe Entomologique de Belgique	Complimentary
Annales Mycologici	Subscription
Annals of Botany	Subscription
Archiv der Gesammte Physiologic (Plfueger)	Subscription
Archiv fuer Hygiene	Subscription
Association Belge des Chimistes, Bulletin	Complimentary
Australian Garden and Field	Complimentary

Beet Sugar Gazette	Complimentary
Berichte der deutschen botanischen Gesellschaft	Subscription
Berichte der deutschen chemischen Gesellschaft	Subscription
Better Fruit	Complimentary
Biedermann's Zentralblatt fuer Agrikultur Chemie	Subscription
Biochemische Zeitschrift	Subscription
Biochemisches Centralblatt	Subscription
Biological Bulletin	Subscription
Biologisches Centralblatt	Subscription
Blooded Stock Farmer	Complimentary
Boletim de Agricultura	Complimentary
Boletim do Instituto Agronomico	Complimentary
Boletin de la Sociedad Nacional de Agricultura	Complimentary
Boletin de Ministero de Frumento	Complimentary
Boston Society of Natural History, Proceedings	Subscription
Botanical Gazette	Subscription
Botanische Zeitung	Subscription
Botaniste, Le	Subscription
Buffalo Society of Natural Sciences, Bulletin	Complimentary
Bulletin de l'Institut Pasteur	Subscription
Bulletin of the Department of Agriculture, Jamaica	Complimentary
Caledonia Era	Complimentary
California Cultivator	Complimentary
California Fruit Grower	Subscription
California University Publications — Botany	Complimentary
Canadian Entomologist	Subscription
Canadian Horticulturist	Complimentary
Centralblatt fuer Bakteriologie, etc	Subscription
Chemical Abstracts	Subscription
Chemical Society, Journal	Subscription
Chemisches Centralblatt	Subscription
Chicago Daily Farmers' and Drovers' Journal	Complimentary
Chicago Dairy Produce	Complimentary
Cincinnati Society of Natural History, Journal	Complimentary
Cold Storage and Ice Trades Review	Complimentary
Colman's Rural World	Complimentary
Colonial Dairy Produce Report	Complimentary
Columbus Horticultural Society, Journal	Complimentary
Connecticut Farmer	Complementary
Commercial Poultry	Complimentary
Country Gentleman	Subscription
Country Life in America	Subscription
Country World	Complimentary
Dairy and Produce Review	Complimentary
Elgin Dairy Report	Complimentary
Elisha Mitchell Scientific Society, Journal	Complimentary

Entomological News	Subscription
Entomological Society of America, Annals	Subscription
Entomological Society of Washington, Proceedings	Subscription
Entomologische Zeitschrift	Subscription
Entomologist	Subscription
Entomologists' Record	Subscription
Farm and Fireside	Complimentary
Farm and Live Stock Journal	Complimentary
Farm and Stock	Complimentary
Farm Journal	Complimentary
Farm Life	Complimentary
Farm News	Complimentary
Farm Poultry	Complimentary
Farm, Stock and Home	Complimentary
Farm Stock Success	Complimentary
Farmers' Advocate	Complimentary
Farmers' Call	Complimentary
Farmers' Guide	Complimentary
Farmers' Magazine (Canadian)	Complimentary
Farmers' Voice	Complimentary
Feather	Subscription
Feathered World	Subscription
Florists' Exchange	Subscription
Flour and Feed	Complimentary
Flour Trade News	Complimentary
Fruit Grower	Complimentary
Fruitman and Gardener	Complimentary
Garden	Subscription
Garden Magazine	Subscription
Gardeners' Chronicle	Subscription
Gardeners' Chronicle of America	Complimentary
Gardening	Subscription
Gartenwelt	Subscription
Gas and Oil Power	Complimentary
Gleanings in Bee Culture	Complimentary
Golden Egg	Complimentary
Grape Belt, The	Complimentary
Green's Fruit Grower	Complimentary
Hartwick Seminary Monthly	Complimentary
Hawaiian Forester and Agriculturist	Complimentary
Hedwigia	Subscription
Herd Register	Complimentary
Hoard's Dairyman	Complimentary
Holstein-Friesian Register	Complimentary
Holstein-Friesian World	Complimentary
Homestead	Complimentary

Hygienische Rundschau	Subscription
Indiana Farmer	Complimentary
Insect World (Japanese)	Complimentary
Ithaca Chronicle	Complimentary
Jahresbericht der Agrikultur-Chemie	Subscription
Jahresbericht Garungs-Organismen	Subscription
Jahresbericht der Nahrungs-und Genussmittel	Subscription
Jahresbericht Pflanzenkrankheiten	Subscription
Jahresbericht der Tier-Chemie	Subscription
Jahresheft Schlesische Insektenkunde	Complimentary
Jersey Bulletin	Complimentary
Journal of Agricultural Science	Subscription
Journal of Agriculture, Victoria	Complimentary
Journal of Biological Chemistry	Subscription
Journal of Board of Agriculture (English)	Complimentary
Journal de Botanique	Subscription
Journal of the College of Agriculture, Tokyo	Complimentary
Journal of the Dept. of Agriculture of Western Australia	Complimentary
Journal of the New Zealand Department of Agriculture	Complimentary
Journal of Economic Biology	Subscription
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal of Industrial and Engineering Chemistry	Subscription
Journal fuer Landwirtschaft	Subscription
Journal of Physiology	Subscription
Just's Botanischer Jahresbericht	Subscription
Kimball's Dairy Farmer	Complimentary
Königleichen Bayerische Akademie der Wissenschaften: Sitzungsberichte der Math.— Phys. Classe	Subscription
Land, The	Complimentary
Lanswirtschaft-Historische Blätter	Complimentary
Landwirtschaftlicher Jahrbucher	Subscription
Landwirtschaftlicher Jahrbuch der Schweiz	Subscription
Landwirtschaftlichen Versuchs-Stationen	Subscription
Live Stock and Dairy Journal	Complimentary
Live Stock Report	Complimentary
Long Island Democrat	Complimentary
Market Fruit-Growers' Journal	Complimentary
Marlboro Record	Complimentary
Memoirs of the Department of Agriculture in India	Complimentary
Metropolitan and Rural Home	Complimentary
Michigan Farmer	Complimentary
Milch Zeitung	Subscription
Milchwirtschaftliches Zentralblatt	Subscription
Minnesota and Dakota Farmer	Complimentary
Mirror and Farmer	Complimentary

Modern Farming	Complimentary
Monthly Bulletin of the N. Y. State Department of Health	Complimentary
Monthly Weather Review	Complimentary
Mycologia	Subscription
National Nurseryman	Complimentary
National Farmer and Stock Grower	Complimentary
National Grange	Complimentary
National Stockman and Farmer	Complimentary
Naturaliste Canadienne	Complimentary
Nebraska Farmer	Complimentary
New England Farmer	Complimentary
New York Academy of Science, Annals and Transactions	Subscription
New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Farmer	Complimentary
New York Fruit and Produce News	Complimentary
New Zealand Dairyman	Complimentary
North American Horticulturist	Complimentary
Northwest Pacific Farmer	Complimentary
Nut Grower	Complimentary
Ohio Farmer	Complimentary
Ohio Naturalist	Subscription
Oklahoma Farm Journal	Complimentary
Orchard and Farm	Complimentary
Pacific Coast Fanciers' Monthly	Subscription
Pacific Fruit World	Complimentary
Pacific Northwest	Complimentary
Parasitology	Subscription
Pennsylvania Farmer	Complimentary
Photo-Miniature	Subscription
Popular Agriculturist	Complimentary
Poultry	Complimentary
Poultry Herald	Subscription
Poultry Husbandry	Complimentary
Poultry Item	Complimentary
Poultry Industry	Complimentary
Poultry Keeper	Complimentary
Poultry Monthly	Complimentary
Power and Engineer	Subscription
Practical Dairyman	Complimentary
Practical Farmer	Complimentary
Practical Fruit Grower	Complimentary
Praktische Blaetter fuer Pflanzenschutz	Subscription
Progressive Farmer	Complimentary
Psyche	Subscription
Rabenhorst's Kryptogamen-Flora	Subscription

Reliable Poultry Journal	Subscription
Republic (St. Louis, Mo.)	Complimentary
Revue Generale de Botanique	Subscription
Revue Generale du Lait	Subscription
Revue Horticole	Subscription
Revue Mycologique	Subscription
Royal Agricultural Society, Journal	Subscription
Royal Horticultural Society, Journal	Subscription
Rural New Yorker	Subscription
Salt Lake Herald	Complimentary
Saint Louis Academy of Science, Transactions	Complimentary
Sanitary Inspector	Complimentary
Science	Subscription
Scientific American	Subscription
Scientific Roll, Bacteria	Subscription
Skaneateles Democrat	Complimentary
Smallholder, The	Complimentary
Society of Chemical Industry, Journal	Subscription
Societe Entomologique Belgique, Annales	Complimentary
Societe Entomologique de France, Bulletin	Complimentary
Societe Mycologique de France, Bulletin	Subscription
Southeast Missouri Farm, Fruit and Poultry	Complimentary
Southern Planter	Complimentary
Southern Tobacconist and Modern Farmer	Complimentary
Southern Farm Magazine	Complimentary
Southwestern Farmer and American Horticulturist	Complimentary
Southwestern Farmer and Breeder	Complimentary
Station, Farm and Dairy	Complimentary
Stazione Sperimentale Agrarie Italiane	Complimentary
Student Farmer, The	Complimentary
Successful Farming	Complimentary
Suffolk Herald	Complimentary
Sugar Beet	Complimentary
Texas Stockman and Farmer	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Transvaal Agricultural Journal	Complimentary
Utica Semi-Weekly Press	Complimentary
Wallace's Farmer	Complimentary
West Indian Bulletin	Complimentary
West Virginia Farm Review	Complimentary
Western Empire	Complimentary
Western Fruit-Grower	Complimentary
Western Plowman	Complimentary
Zeitschrift fuer Analytische Chemie	Subscription

Zeitschrift fuer Biologie	Subscription
Zeitschrift fuer Hygiene und Infektions Krankheiten	Subscription
Zeitschrift fuer Pflanzenkrankheiten	Subscription
Zeitschrift fuer Physiologische Chemie	Subscription
Zeitschrift fuer Untersuchung der Nahrungs and Genusmittel.	Subscription
Zentralblatt fuer Biochemie und Biophysik	Subscription
Zoological Record	Subscription
Zoologischer Anzeiger	Subscription

METEOROLOGICAL RECORDS FOR 1910.

METEOROLOGICAL RECORDS FOR 1910.

Reading of the Standard Air Thermometer.

DATE.	January.			February.			March.			April.			May.			June.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	17.	31.	36.	16.	28.	25.	34.	43.	43.	42.	57.5	60.	49.	58.	59.	48.	51.	49.
2	38.	34.	32.	22.	40.	34.	37.	40.	42.	44.	58.	57.	57.	68.	70.	49.	50.	60.
3	26.	28.	22.	33.	30.	24.	32.	43.	42.	41.	60.	65.	46.	44.	43.	51.	54.	56.
4	2.	5.	—2.	20.	33.	28.	31.	45.	44.	42.	55.	63.	43.	51.	53.	47.	58.	57.
5	16.	22.	31.	19.5	21.	14.	38.	51.	53.	55.	75.	77.	43.	51.	53.	50.	52.	52.
6	27.	25.	23.	4.	3.	0.	34.	49.	54.	60.	55.	55.	44.	53.	59.	56.	65.	59.
7	23.	23.	19.	—3.	12.	21.	35.	35.	29.	35.	31.	31.	52.5	65.	68.	50.	54.	58.
8	9.	19.	26.	19.	34.	37.	25.	33.	34.	32.	34.	47.	48.	58.	62.	57.	64.	72.
9	20.	32.	25.	38.	38.	35.	29.	31.	31.	41.	57.	55.	50.	60.	60.	62.	70.	71.
10	12.	16.	10.	19.	19.	16.	22.	34.	33.	41.	50.	50.	46.	63.	62.	59.	67.	65.
11	13.	25.	26.	2.	18.	19.	21.	37.	40.	35.	42.	30.	44.	53.	53.	53.5	59.	60.
12	16.	32.	28.	15.	23.	18.	28.	42.	44.	33.	42.	43.	42.	53.	51.	62.	66.	64.
13	16.	27.	21.	19.	25.5	22.5	35.	45.	37.	36.	52.	58.	41.	49.	51.	63.5	73.	79.
14	22.	22.	20.	19.	33.	28.	18.	21.	20.	43.	57.	69.	40.	49.	47.	65.	81.	83.
15	16.	19.	13.	30.	33.	26.	19.	24.	31.	49.	70.	59.	47.	59.	58.	67.5	83.	81.
16	11.	21.	16.	40.	35.	22.	34.	38.	33.	50.	63.	64.	49.	63.	65.	65.	71.	70.
17	11.5	24.	35.	14.	18.	14.	19.	26.	25.	44.	49.	50.	55.	71.	66.	70.	79.	75.
18	36.	39.	38.	13.	17.	15.	24.	38.	41.	52.	64.	59.	54.	57.	61.	69.	78.	72.
19	30.	28.	26.	2.	26.	22.	35.	53.	66.	47.	63.	45.	47.	60.	67.	70.	80.	82.
20	14.	37.	40.	14.	33.	34.	53.	52.	48.	40.	50.	47.	56.	75.	65.	71.	80.	85.
21	38.	38.	40.	38.	37.	35.	32.	44.	53.	44.	51.	55.	60.5	71.	74.	69.	85.	82.
22	41.	34.	28.	21.	20.	20.	41.	60.	59.	48.	63.	63.	59.	73.	67.	70.	87.5	88.
23	24.	29.	33.	14.	14.	13.5	34.	49.	48.	48.	51.	47.	62.	69.	72.	74.	84.	78.
24	28.	36.	32.	0.	15.	14.	47.	72.	77.	45.	55.	55.	69.	71.	67.	67.	74.	75.5
25	27.	28.	27.	6.	20.	17.	58.	64.	49.	56.	60.	63.	58.	60.	57.	70.	75.	80.
26	27.	28.	32.	16.	28.	33.	39.	48.	47.	60.	61.	58.	49.	61.	60.	69.	83.	84.
27	32.	35.	34.	40.	44.	41.	38.	49.	55.	45.	54.	51.	47.	51.	53.	68.	83.	79.
28	28.	31.	30.	35.	36.	35.	52.	76.	75.	35.	42.	46.	55.	70.	73.	65.	76.	79.
29	26.	24.	25.	......	......	......	46.	71.	79.	38.	39.	41.	56.	73.	68.	62.5	82.	81.
30	19.	32.	26.	......	......	......	60.	72.	71.	57.	68.	57.	57.	49.	55.	69.5	84.	79.
31	24.	27.	25.	......	......	......	52.	64.	54.	......	......	......	48.	54.	50.	......	......	......
Averages	22.3	27.5	26.4	18.9	26.2	23.7	35.5	46.7	47.	44.6	54.3	54.3	51.1	60.1	60.3	62.4	71.9	71.8

READING OF THE STANDARD AIR THERMOMETER — (*Concluded*).

DATE.	July.			August.			September.			October.			November.			December.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	72.	82.	84.	63.5	75.5	78.	60.	70.	71.	65.	73.	65.	38.	56.	56.	28.	28.	25.
2	60.5	83.	87.	65.	80.	79.	58.	70.	74.	43.	51.	53.	50.	43.	43.	19.	23.	23.
3	70.	87.	88.	65.	83.	87.	62.	66.	75.	50.	65.	65.	36.	37.	34.	25.	29.	28.
4	61.	73.	77.	71.	83.	74.	63.	68.	70.	63.	73.	70.	33.	35.	36.	23.	27.	23.
5	65.	80.	83.	59.5	63.	69.	66.5	76.	76.	67.	75.	68.	36.	35.	38.	14.	19.	15.
6	70.	84.	87.	61.	69.	67.	71.	84.	78.	65.	79.	59.	38.	40.	36.	7.	18.	15.
7	68.	70.	80.5	63.	71.	74.	64.	74.	74.	42.	50.	49.	30.	39.	35.	15.	19.	22.
8	72.	84.	83.	60.	77.	70.	61.	70.5	73.	40.	53.	54.	31.	36.	35.	22.	22.	21.
9	71.	92.	96.	61.5	75.5	75.5	61.	68.	62.	51.	56.	53.	35.	34.	39.	15.	19.	12.
10	78.	94.	77.	66.	68.	65.	52.	63.	67.	45.	48.	53.	46.	54.	44.	6.	25.	17.
11	70.	82.	84.	63.	74.	77.	56.	69.	69.	54.	67.	65.	43.	35.	32.	12.	18.	13.
12	68.	82.5	72.	66.	79.	80.	62.	79.	78.	49.	49.	43.	29.	31.	32.	18.	20.	15.
13	69.	73.	79.	65.	87.	87.5	62.	56.	55.	30.	50.	52.	33.	33.	33.5	17.	18.	17.
14	68.	81.	82.	71.	81.	86.	50.	61.	61.	50.5	71.	56.	31.	36.	34.	34.	37.	36.
15	70.	85.	86.	69.	84.	86.	52.	68.	66.	54.	60.	56.	31.	32.	32.	37.	31.	14.
16	66.	65.	63.5	69.5	81.	85.	51.	69.	70.	61.	65.	59.	31.	33.	34.	8.	10.	6.
17	64.	72.	73.	67.	79.	73.	52.	67.	71.	44.	63.	62.	33.	35.	35.	15.	24.	27.
18	65.	75.	75.	61.5	73.	68.5	63.	64.	61.	49.	72.	70.	33.	35.	33.	19.	30.	33.
19	65.	76.	77.	62.	74.	75.	51.	66.	67.	52.	75.	71.	31.	31.	28.	33.	36.	32.
20	66.5	80.	79.5	68.	74.	72.	58.	69.	72.	59.	73.	53.	28.	33.	30.	24.	26.	20.
21	69.	86.	75.	64.	78.	84.	56.	68.	63.	48.	48.	55.	28.	37.	38.	10.	13.	12.
22	65.	78.5	79.	64.	80.	83.	50.	56.	58.	53.	54.	51.	34.	39.	36.	10.	29.	21.
23	66.	85.	86.5	67.	82.	83.	55.	73.	69.	43.	45.	47.	29.	42.	42.	28.	33.	33.
24	77.	92.	93.	70.	84.	83.	55.	62.	66.	38.	56.	57.	30.	42.	40.	33.	32.	26.
25	75.	81.	84.	71.	85.	87.	67.	75.	65.	49.	49.	45.	36.	41.	39.	16.	18.	11.
26	63.5	74.	78.	57.	60.	66.	57.	62.	59.	33.	52.	46.	33.	35.	34.	21.	27.	30.
27	70.5	85.	81.	56.	70.	71.	61.	71.	72.	49.5	63.	48.	33.	35.	29.	28.	37.	38.
28	63.	76.	79.	59.	76.	76.5	53.	61.	59.	39.	46.	41.	28.	37.	36.	31.	31.	38.
29	64.	80.	85.	57.	75.	73.	50.	65.	65.	32.	39.	32.5	33.	37.	33.	32.	36.	34.
30	70.	75.	73.	59.	77.	78.	52.	70.	69.	30.	42.	40.	31.	34.	32.	29.	20.	11.
31	64.	72.	74.	67.	72.	68.	......	......	......	39.	53.	47.	......	......	......	—1.	18.	23.
Averages	68.2	80.2	80.7	64.1	76.5	76.8	57.7	68.	67.8	48.	58.6	54.4	33.7	37.4	35.9	20.2	24.9	22.3

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1910.

DATE.	January.		February.		March.		April.		May.		June.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	37.	12.	29.	15.	44.	33.	63.	38.	63.	43.	52.	44.
2	45.	32.	48.	14.	44.	35.	62.	37.	70.	51.	61.	44.5
3	32.	22.	34.	23.	45.	30.	68.5	29.	70.	42.	61.	44.
4	23.	—2.	35.	17.	49.	26.	84.	49.	53.	37.	60.5	36.
5	31.	—8.	13.	29.5	59.	32.5	80.	53.	55.	36.	59.	38.
6	35.	22.	13.	0.	57.	31.	72.	49.	59.	37.	68.	50.
7	23.	18.	23.	—3.	54.	27.	54.	27.	69.	45.	59.	47.
8	27.	4.	39.	14.	35.	24.	47.	20.	62.	39.	73.	49.
9	35.	19.	39.	30.	35.	25.	57.	37.	65.	52.	74.	48.
10	35.	9.	35.	12.5	38.	21.	57.	33.	64.	41.	71.	51.
11	28.	—1.	19.5	1.	43.	20.	50.	32.	62.	42.	66.	52.
12	33.	22.	24.5	0.	48.	26.	45.	29.	57.	35.	68.	57.
13	29.	10.	26.	16.	46.	30.	58.	28.	53.	33.	80.	55.
14	22.	18.	33.	17.	30.	17.	71.	32.	52.	33.5	84.	52.
15	20.	13.	34.	21.	32.	18.	70.	40.	62.	40.	88.	57.
16	28.	4.	49.	22.	41.	26.	66.	46.	66.	31.5	88.	57.
17	35.	3.	22.	12.	33.	18.	63.	35.	73.	42.5	88.	57.
18	41	31.	19.	12.	41.	17.	66.	46.	67.	45.	80.	60.
19	41.	25.	28.	—1.	68.	28.	62.	44.	69.	40.	85.	62.
20	40.	15.	35.	12.	61.	46.	52.	33.	79.	44.	89.	56.
21	43.	15.	38.	31.	54.	29.	57	42.	76.	56.	87.	59.
22	45.	24.	35.	19.	63.	38.	67.	43.	75.	51.	89.9	60.
23	33.	21.	22.	9.	59.	31.	60.	42.	73.	58.	88.	65.
24	37.	26.	20.	0.	82.	34.	58.	42.	74.	59.	79.	57.
25	32.	26.	23.	0.	72.	48.	64.	52.	67.	56.	81.	51.
26	32.	20.	33.	6.	50.	33.	64.	54.	64.	47.	86.	55.
27	36.	30.	45.	16.	57.	27.	60.	36.	62.	45.	86.	64.
28	35.	27.	42.	33.	78.	41.	52.	30.	74.	48.	81.	59.
29	30.	22.	......	......	80.5	43.	47.	31.	76.	45.	87.	59.
30	32.	17.	......	......	79.	58.	74.	39.	75.	47.	86.	59.
31	28.	22.	......	......	71.	51.	......	......	55.	43.	......	......
Averages	33.	17.1	30.6	13.6	53.2	31.1	61.7	38.6	65.8	44.	76.9	53.5

READING OF MAXIMUM AND MINIMUM THERMOMETER FOR 1910 — (*Concluded*).

DATE.	July.		August.		September.		October.		November.		December.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	89.	64.	80.	50.5	71.	59.	73.	44.	59.	35.	32.	25.
2	87.	66.	83.	58.	74.	51.	65.	42.	57.	41.	25.	18.
3	92.	65.5	90.	57.	77.	51.	72.	40.	43.	34.	30.	20.5
4	79.	60.	87.	58.	76.	61.	77.	59.	37.	32.	33.	20.
5	84.	50.	70.	53.	82.	63.	75.	66.	42.	35.	23.	14.
6	88.	54.	69.	58.	87.	68.	81.	59.	42.	35.	22.	3.
7	80.5	63.	78.	56.	78.	61.	59.	46.	41.	28.	22.	8.
8	88.	65.	78.	57.	76.	56.	59.	33.	38.	30.	26.	20.
9	96.5	70.	78.5	56.	73.	59.	57.	48.	39.	33.	21.	12.
10	94.5	70.	75.	64.	70.	45.	56.	44.	56.	37.	28.	5.
11	87.	64.	78.	57.	73.	47.	71.	41.	43.	32.	19.	12.
12	89.	58.	82.	52.	83.	58.	65.	43.	35.	27.	23.	8.
13	79.	67.	87.5	56.	78.	54.	55.	28.	34.	30.	20.	13.
14	85.	55.	89.	66.	64.	47.	72.	45.	36.	30.	39.	12.
15	87.	86.	90.	61.	73.	40.	62.	48.	37.	31.	37.	14.
16	86.	60.	88.	65.	74.	44.	66.	49.	35.	29.	14.	6.
17	74.	55.	85.	65.	76.	44.	69.	40.	37.	31.	27.	3.
18	77.	53.	73.	60.5	72.	52.	79.	40.	35.	32.	34.	18.
19	79.	57.	77.	55.5	71.	49.	79.	49.	33.	28.	36.	30.
20	83.	52.	70.	50.	76.	55.	74.	53.	34.	27.	33.	20.
21	86.	58.	85.	50.	72.	53.	57.	43.	38.	24.	21.	8.
22	83.	63.	84.	61.	63.	43.	58.5	50.	40.	33.	30.	7.
23	89.	61.	86.	64.	77.	40.	50.	41.	43.	21.	34.	19.
24	94.5	60.5	87.	68.	69.	54.	63.	37.	47.	37.	36.	26.
25	86.	65.	88.	66.	78.	64.	57.	44.	42.	35.	26.	11
26	80.	62.	66.	54.	65.	56.	54.	32.	39.	31.	30.	2.
27	87.	62.	73.	44.	76.	56.	63.5	41.	35.	29.	40.	12.
28	81.	61.	79.	49.	72.	50.	48.	35.	29.	24.	38.	26.
29	86.	54.	79.	52.	70.	46.	41.	30.	37.	32.	41.	31.
30	83.	64.	81.	47.5	76.	46.	46.	26.	35.	30.	34.	11.
31	74.	56.	79.	62.5	....	......	57.	33.	.....	......	25.	— 2.5
Averages	85.	61 3	80.8	57.2	74.1	52.4	63.3	42.9	40.3	31.1	29.	14.

SUMMARY OF AVERAGES OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Maximum	33.	30.6	53.2	61.7	65.8	76.9	85.	80.8	74.1	63.3	40.3	29.
Minimum	17.1	13.6	31.1	38.6	44.	53.5	61.3	57.2	52.4	42.9	31.1	14.
Standard, 7 A. M.	22.3	18.9	35.5	44.6	51.1	62.4	68.2	64.1	57.7	48.	33.7	20.2
Standard, 12 M.	27.5	26.2	46.7	54.3	60.1	71.9	80.2	76.5	68.	58.6	37.4	24.9
Standard, 5 P. M.	26.4	23.7	47.	54.3	60.3	71.8	80.7	76.8	67.8	51.4	35.9	22.3

AVERAGE MONTHLY AND YEARLY TEMPERATURE SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly averages.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.8	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	65.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	......
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	25.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	......
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	53.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.4	45.9	60.4	63.2	70.8	65.5	64.4	52.5	30.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
1907	24.9	19.5	38.1	40.2	51.3	64.0	71.2	68.4	64.4	47.9	38.7	31.8	46.7
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.8	67.0	52.9	40.0	29.2	48.8
1909	27.7	28.6	31.0	44.3	57.9	67.2	69.6	70.0	63.5	47.7	44.5	25.7	48.1
1910	25.1	22.1	42.1	50.1	54.9	65.2	73.1	69.0	63.2	53.1	35.7	21.5	47.9
Monthly averages	23.4	22.9	30.8	44.3	56.4	66.4	71.0	68.8	62.6	50.1	38.7	27.8	46.9

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1910 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	JANUARY.				FEBRUARY.				MARCH.				APRIL.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	18.	44.	11.	—9.	17.	48.	24.	—2.	19.	61.	9.	2.	16.	75.	1.	19.
1884	14.	42.	26.	—13.	7.	55.	29.	—3.	30.	54.	1.	—4.	28.	74.	1.	23.
1885	1.	61.	29.	—6.	10.	38.	11.	—11.5	28.	48.	13.	—11.	24.	84.5	10.	20.5
1886	5.	52.5	13.	—18.7	9.	50.	27.	—11.	16.	58.	2.	—2.5	24.	80.5	4.	22.
1887	24.	50.7	19.	—8.	9.	54.2	27.	—4.	3.	51.7	1 & 5	8.7	11.	75.7	1.	17.2
1888	2.	43.2	23.	—6.	21.	49.	10.	—7.	28.	57.	13.	0.	29.	82.5	8.	19.
1889	18.	55.	20.	5.	23.	42.	4 & 24	—7.	28.	61.8	30.	18.5	20.	84.	1.	26.
1890	6.	67.	29.	9.	5.	**64.5**	11 & 21	9.5	13.	62.	8.	2.	13.	78.8	1 & 19	23.
1891	3.	46.	17.	4.	26.	56.8	15.	2.5	12.	57.	2.	4.5	28.	81.4	7.	21.
1892	3.	48.	10.	—5.	15.	44.	6.	2.8	27.	52.2	4.	6.	6.	78.	17.	25.5
1893	29.	46.	11.	—6.	15.	47.4	5.	—1.	24.	54.	5.	9.	13.	75.3	26.2	25.
1894	5.	59.	13.	11.	20.	47.6	27.	—8.5	18.	73.	26.	15.	21.	71.3	2.	20.
1895*	7.	45.	19.	4.	25.	46.	8.	—14.	25.	52.	5 & 16	12.	30.	80.	3.	28.
1896	30.	44.	6.	—16.5	29.	49.	17.	**—21.**	31.	56.5	24.	—2.	17.	**87.**	4 & 5	19.
1897	5.	58.	20.	—3.5	18.	49.5	1 & 27	5.5	21.	64.	1.	—1	26.	82.	20.	19.
1898	13.	57.	30 & 31	—4.	12.	56.5	2 & 3	—2.	11.	†55.	2.	17.5	14 & 18	60.	9.	18.
1899	5.	59.	12.	—4.	21.	52.5	11.	—8.	13.	63.	21.	13.	30.	82.	3.	23.
1900	23.	56.	1.	2.	14.	57.	27.	0.	10.	46.	12.	—3.	30.	‡73.5	9.	22.
1901	16.	48.	20.	—2.	16.	36.	24.	—2.5	24.	67.	6.	—1.	28.	78.	12.	28.
1902	3.	44.	28.	2.	28.	52.	6.	—3.	12.	66.5	19.	14.	22.	**87.**	5.	25.
1903	3.	48.	9.	—2.	28.	62.5	18.	—4.	19.	78.5	1 & 2	19.	30.	86.	5.	21.
1904	23.	48.	19.	—14.	7.	58.	16.	18.	26.	58.	4.	8.	24.	67.5	14.	**16.**
1905	1.	49.	26.	—2.	20.	45.	5 & 14	—6.	29.	**82.**	5.	1.	27 & 28	75.	16.	23.
1906	21.	**71.**	9.	4.	24.	64.	6 & 7	—7.	27.	51.	25.	2.	19.	74.	2.	25.
1907	6.	53.	24.	—18.	2.	47.	12.	—4.	29.	83.	7.	—1.	29.	73.	2.	19.
1908	22.	45.	31.	—9.	15.	53.	2 & 5	—14.	28.	73.	1.	8.	27.	78.	4.	18.
1909	24.	64.	19.	—7.	5.	52.	1.	—1.	10.	52.	5.	5.	19.	75.	11.	12.
1910	2 & 22	45.	5.	—8.	16.	49.	7.	—3.	24.	**82.**	14 & 18	17.	4.	84.	7.	27.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Maximum for first eleven days only. Record incomplete.
‡ Thermometers broken, Record not taken from April 19th to 24th inclusive.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1910 INCLUSIVE — (*Continued*).
(Highest and Lowest Record for Each Month in Heavy Type.)

	MAY.				JUNE.				JULY.				AUGUST.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	11.	87.	1 & 14	31.	7.	86.5	2.	42.	5.	89.	1.	46.	23.	92.	15.	46.
1884	24.	88.	30.	32.	25.	90.5	15.	41.	2.	87.5	15.	50.5	20.	95.	25.	44.
1885	18.	81.7	3.	27.5	14.	86.5	23.	41.5	18.	90.5	12.	46.5	1.	89.	28.	45.
1886	23.	79.5	17 & 18	37.2	14.	86.2	1.	42.2	7.	95.	1.	45.2	30.	91.5	6.	47.7
1887	23.	88.2	14.	37.5	17.	89.2	15.	47.7	3.	95.5	11.	58.7	3.	88.5	8.	46.
1888	13.	79.8	3.	20.	23.	91.1	4.	40.	5.	89.8	16.	47.	9.	92.6	23.	48.3
1889	18.	91.8	29.	32.	22.	85.	5.	46.	11.	90.7	6.	50.5	31.	86.7	16 & 17	50.3
1890	4.	80.7	2.	30.	30.	85.6	8.	44.8	9.	94.5	24.	46.5	4.	96.2	24.	46.0
1891	11.	85.5	4.	29.5	16.	95.	6.	40.	14.	92.	31.	46.	12.	92.	29.	46.5
1892	31.	78.	9.	34.2	14.	92.	11.	45.8	29.	96.3	2.	46.4	10.	95.5	28.	49.
1893	25.	88.	9.	35.	21.	94.	1.	44.	26.	95.5	24.	48.4	11.	94.5	13.	49.
1894	2.	85.4	14.	32.6	23.	91.6	6.	39.	21.	97.	10.	49.6	25.	93.	27.	45.3
1895*	31.	**92.**	13 & 21	36.	3.	**96.**	7.	54.	8.	94.	11.	52.	11.	88.	22.	44.
1896	11.	87.5	7 & 20	40.	21.	89.	3.	41.	3.	91.	18.	49.	6 & 7	96.	29.	44.
1897	24.	80.	8.	32.5	24 & 25	87.5	2.	42.	11.	97.	15.	57.	15.	87.5	21.	46.
1898	29.	79.	6.	34.	9.	90.	16.	40.	4.	95.5	12.	**40.**	24.	90.5	28.	47.
1899	2.	87.5	15.	32.5	6 & 21	93.	11.	41.5	4.	**97.5**	1.	50.	20.	97.5	15.	44.5
1900	15 & 16	88.5	7.	27.	25.	93.	10.	45.	17.	96.	1.	50.	11.	97.	2.	51.
1901	23.	78.	16.	36.	27, 28 & 20	95.5	2.	42.	1.	97.5	20.	54.5	22.	90.	5.	52.
1902	22.	90.	11.	26.	3.	85.	6.	38.	14 & 27	90.	1.	53.	31.	90.	13.	47.
1903	19.	80.	2.	**24.**	30.	86.5	1.	39.	9.	94.	15.	50.	18.	85.5	8 & 14	45.
1904	25.	88.	12.	31.5	5–24 & 25.	89.	12 & 17	45.	19.	93.	3.	49.	25.	89.5	19.	45.
1905	3.	82.	2.	29.5	19.	90.	1.	40.	18.	92.	22.	48.5	10.	93.	27.	**41.**
1906	24.	88.5	11 & 21	30.	8.	92.	12.	**37.**	20–22 & 23	89.	25.	50.	5.	93.	16.	47.
1907	14.	85.	2–11 & 12	28.	18.	94.	3.	41.	16.	90.	4.	46.	12.	96.5	19.	41.5
1908	29.	90.	1–4 & 5	31.	19.	92.	12.	43.	6–11 & 30	94.	9.	52.	4.	95.	25.	46.
1909	31.	78.	2 & 3	33.	28.	90.	8.	43.	15.	92.	4.	42.	8.	**98**	31.	42.
1910	20.	79.	16.	31.5	22.	89.9	4.	36.	9.	96.5	5.	50.	3 & 15	90.	27.	44.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

Monthly Maximum and Minimum Temperatures from 1883 to 1910 Inclusive — (*Concluded*).
(Highest and Lowest Record for Each Month in Heavy Type.)

	September.				October.				November.				December.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	17.	80.	11.	37.	11.	78.	17 & 18	25.	22.	70.	17.	13.	9 & 14	56.	23.	—7.5
1884	5.	94.	14.	36.	5.	84.2	27.	23.	11.	62.	25.	15.	31.	55.5	20.	**—15.5**
1885	27.	83.7	24.	40.	1.	79.	31.	25.	8 & 13	68.	28.	18.	24.	53.	9.	4.
1886	11.	89.5	22.	49.	10.	76.7	17.	27.5	3.	68.2	28.	17.	11 & 25	40.	6.	—6.
1887	22.	81.7	27.	37.2	9.	78.5	31.	**21.2**	28.	68.	30.	15.	12.	54.7	2.	—3.
1888	1 & 10	83.	7.	40.	6.	62.7	22.	29.	1 & 3	**73.**	23.	**8.**	27.	53.	22.	4.
1889	4.	84.	22 & 23 & 29	40.	2.	68.7	24.	21.2	4.	61.7	17.	17.8	25.	60.5	4 & 5	8.
1890	8.	83.6	25.	35.5	5.	69.8	31.	32.	8.	65.4	28.	17.	1.	46.2	20.	3.
1891	26.	92.8	30.	43.	4.	89.4	12 & 25	27.	1.	68.	29.	12.	5.	57.7	18.	7.
1892	26.	88.	20.	39.	1.	82.	2.	33.1	19.	60.	24.	18.	9.	49.2	27.	—3.7
1893	5.	80.	26.	37.4	13.	76.	31.	25.	3.	62.	27.	19.	26.	62.	14.	1.5
1894	4.	90.	26.	33.	1.	76.5	15.	33.	3.	65.	29.	12.	17.	59.	29.	—0.2
1895*	4.	94.	15 & 30	42.	2.	72.	30.	28.	7.	68.	21.	19.	20 & 21	62.	13.	—2.
1896	12.	95.	23.	36.	30.	77.5	10 & 19	29.	19.	70.	21.	19.5	14.	58.	28.	2.
1897	11.	**98.**	21.	37.5	16.	88.	10 & 18	30.	6.	65.	24.	16.5	12.	**61.5**	24.	2.
1898	4.	94.	21.	40.5	1.	85.5	28.	31.	5.	63.	28.	16.	31.	54.	14.	3.
1899	4.	92.	15 & 30	**30.**	15.	86.	3.	26.	19.	60.	14.	25.	12.	60.	31.	—1.
1900	12.	95.	19.	37.	6 & 7	**89.**	20.	28.	22.	70.	17.	19.	4.	55.	10 & 14	4.
1901	6.	89.	26.	36.	10 & 11	74.	28.	28.	1.	65.	27.	13.	14.	62.	18.	—1.
1902	1.	90.	15.	38.	19.	71.	10 & 22 & 30	29.	14.	73.	29.	22.	2.	52.	9.	—5.
1903	14.	90.	29.	35.	1.	73.	25 & 27	28.	4.	70.	26 & 27	12.	3.	46.	19.	—4.
1904	3.	88.	23.	33.	10.	81.	31.	22.	3.	65.	29.	9.	23.	53.	16.	—2.
1905	30.	88.5	26.	36.	1.	85.	26.	**20.5**	12.	61.	14.	11.	29.	52.5	15.	1.
1906	18.	91.5	25.	38.	5.	79.5	13 & 31	30.	19.	62.	30.	16.	6.	52.	8.	—1.
1907	20.	90.	27.	39.	†3.	80.	31.	24.	1.	59.	12 & 16	22.	30.	57.	22.	13.5
1908	10.	92.	30.	37.	18.	83.	21.	27.	26.	68.	5.	18.	1.	**64.**	23.	3.
1909	14.	93.	2 & 6	35.	9.	82.5	29 & 30	27.	11.	**75.**	24.	21.	6	45.	30.	1.
1910	6.	87.	15 & 23	40.	6.	81.	30.	26.	1.	59.	23.	21.	29.	41.	31.	—2.5

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Thermometer broken on the 27th, 28th, and 29th of October.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1910 INCLUSIVE.
(Highest and Lowest Record for the Time in Heavy Type).

	MAXIMUM FOR EACH YEAR.		MINIMUM FOR EACH YEAR.	
	Date.	Temp.	Date.	Temp.
1883	Aug. 23	92.	Jan. 11	— 9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	— 8.
1888	June 23	94.1	Feb. 10	— 7.
1889	May 18	91.8	Feb. 4 and 24	— 7.
1890	Aug. 4	96.2	Mar. 8	2.
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	— 5.
1893	July 26	95.5	Jan. 11	— 6.
1894	July 21	97.	Feb. 27	— 8.5
1895*	June 3	96.	Feb. 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	**—21.**
1897	Sept. 11	98.	Jan. 20	— 3.5
1898	July 4	96.5	Jan. 30 and 31	— 4.
1899	July 4 and Aug. 20	97.5	Feb. 11	— 8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.5
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	— 5.
1903	July 9	94.	Feb. 18 and Dec. 19	— 4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	— 6.
1906	Aug. 5	93.	Feb. 6 and 7	— 7.
1907	Aug. 12	96.5	Jan. 24	—18
1908	Aug. 4	95.	Jan. 2 and 5	—14.
1909	Aug. 8	**98.**	Jan. 19	— 7.
1910	July 9	96.5	Jan. 5	— 8.

* Data from record kept by Mr. Edgar Parker; Station record not available.

RAINFALL BY MONTHS SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.40	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24*	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	2.88	0.90+	4.02	2.73	3.47	2.02	1.24	20.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	4.26	1.07	4.34	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	2.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	....
1896	1.19	2.28	0.81	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.10	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.02	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.60
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.32	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.08	2.16	3.56	1.40	1.54	20.93
1907	1.89	0.03	1.14	2.42	1.82	2.34	2.86	1.35	2.73	2.48	2.78	1.89	24.73
1908	0.68	1.12	1.24	3.28	3.57	1.90	4.72	1.79	1.66	2.73	0.88	0.43	24.00
1909	0.94	1.68	1.35	3.20	2.83	2.17	2.04	2.21	2.22	1.18	0.56	0.49	20.87
1910	0.87	0.53	0.28	4.56	3.45	1.55	2.39	5.47	3.29	1.73	0.62	0.38	25.12

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